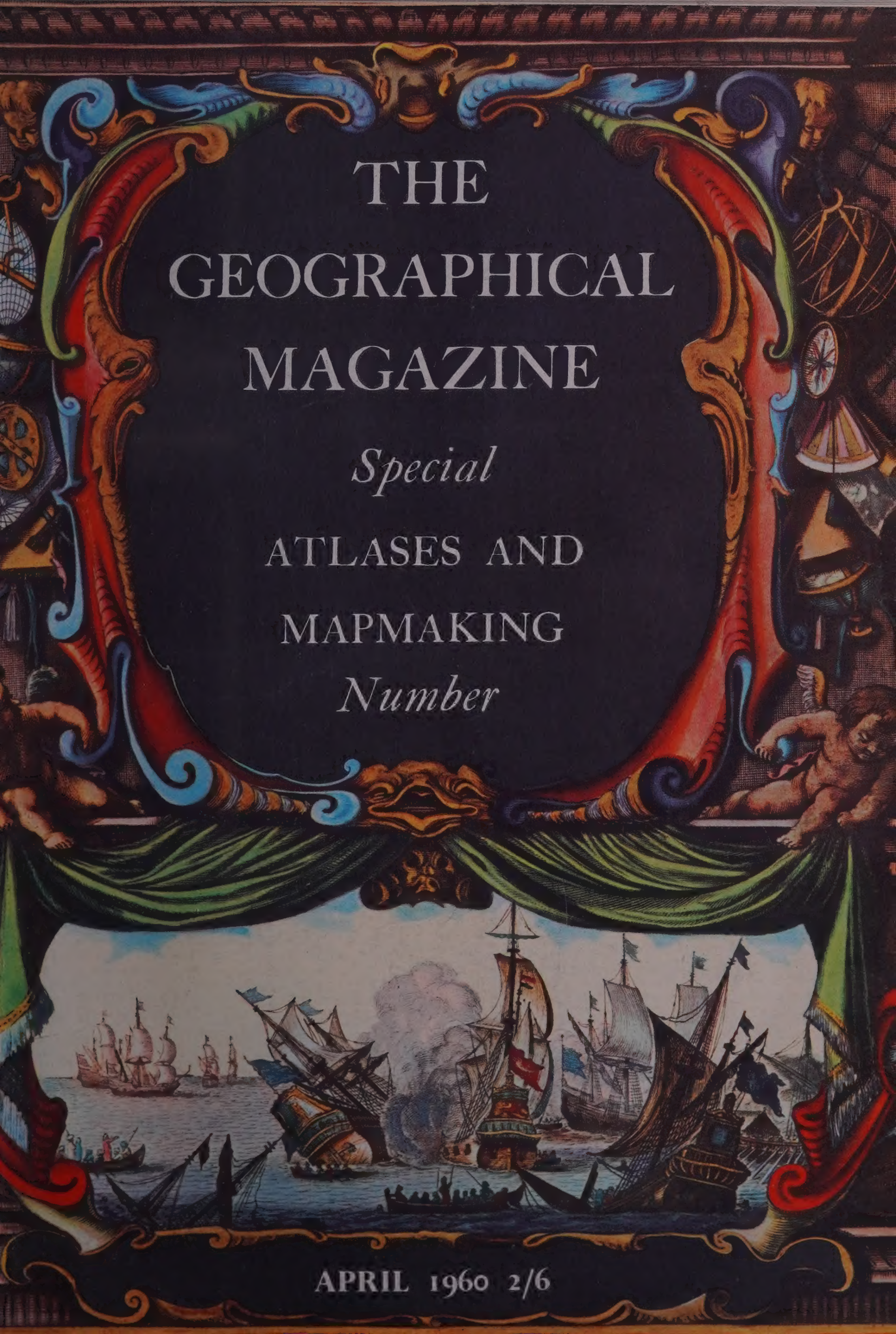


THE GEOGRAPHICAL MAGAZINE

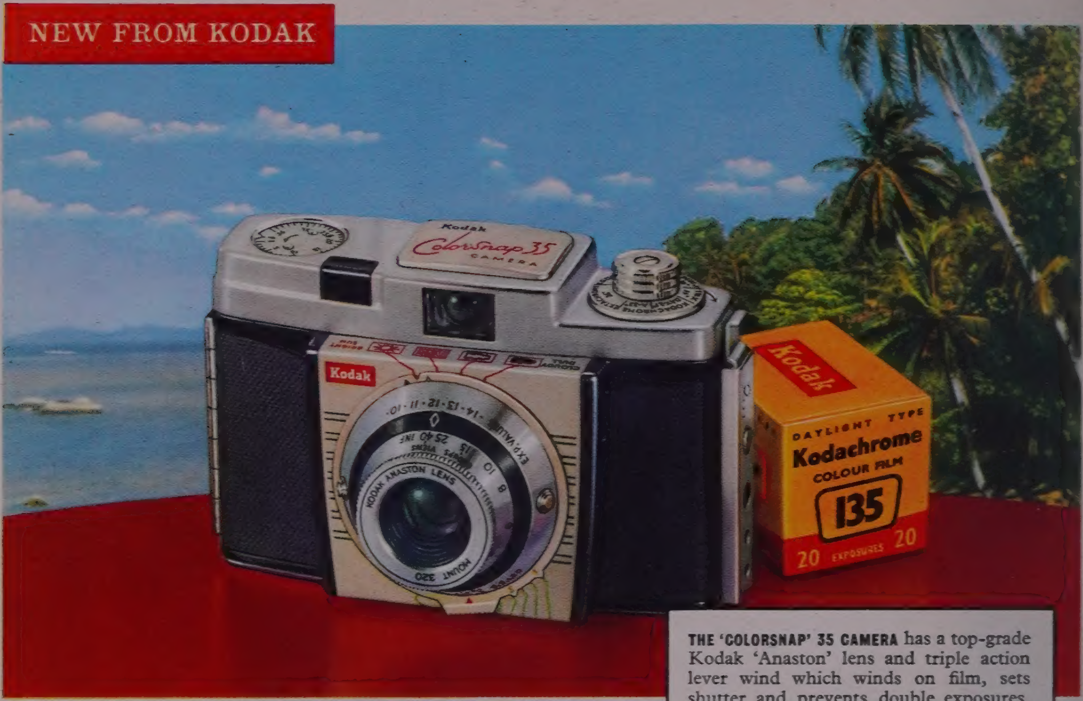
Special

ATLASES AND

MAPMAKING

Number

APRIL 1960 2/6



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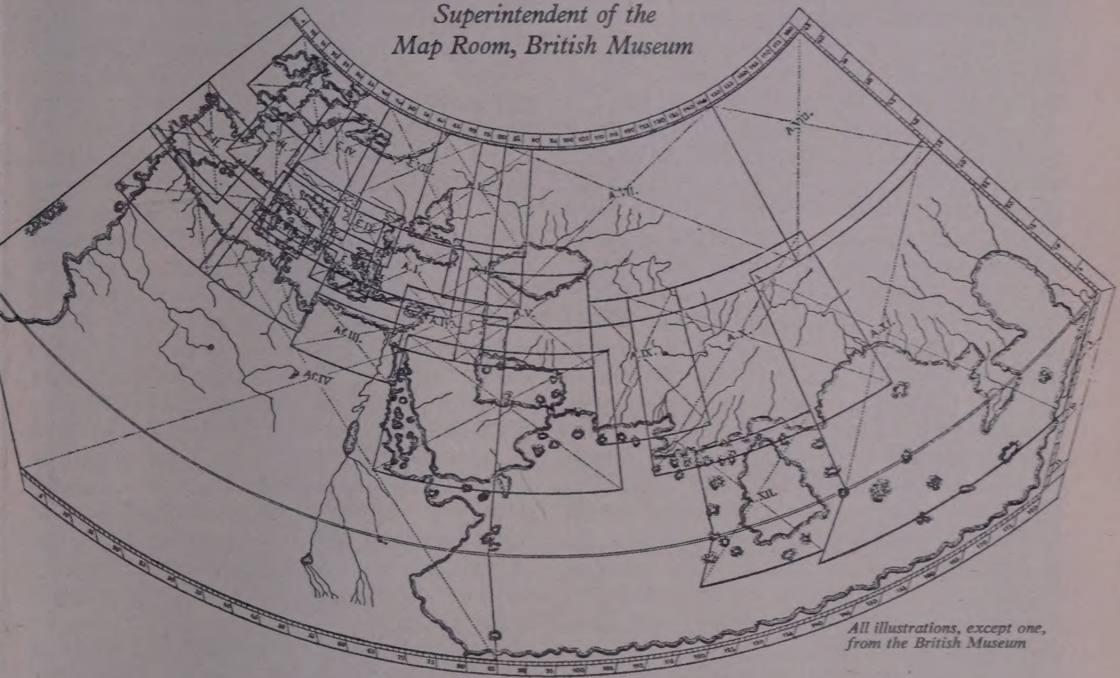
Early Atlases

by

R. A. SKELTON

Superintendent of the Map Room, British Museum



All illustrations, except one, from the British Museum

(Fig. 1) Ptolemy's world map, showing the coverage of his twenty-six regional maps. (Reproduced from A. E. Nordenskiöld's *Facsimile Atlas*, 1897)

THE BIRTH OF THE ATLAS: 16TH CENTURY

THE atlas published in 1570 by Abraham Ortelius, under the title *Theatrum Orbis Terrarum*, is often described as the "first modern atlas". This is true only in a narrow sense, for there had been many earlier manuscript and printed works which satisfied the dictionary definition of an atlas as "a collection of maps bound in a volume". In the 14th and 15th centuries, for instance, a group of portolan charts embracing the known or navigable world was often gathered by its author into a codex or bound volume. Some of the Greek manuscripts of Ptolemy's *Geographia*, brought to Italy at the beginning of the 15th century, were accompanied by a world map and twenty-six regional maps (ten for Europe, four for Africa, twelve for Asia) compiled from his tables of co-ordinates. These maps were copied in the Latin version and, after being redrawn at Florence about 1460, were engraved on copper and first printed with Ptolemy's text in 1477. Drawn on a uniform projection, they provided a systematic cover of the whole habitable world known to Ptolemy (Fig. 1), and in this sense may be called a world atlas—but not a "modern atlas".

To the 1482 edition of the *Geographia* (the first with woodcut maps) were added five *tabulae modernae*, or modern maps, of European countries and the Holy Land; and in successive 16th-century editions of Ptolemy the number of such maps was gradually increased by editors who grafted the new geography of the great discoveries on the old stock of Ptolemy. The Strassburg edition of 1513, with a section of twenty *tabulae modernae* by Martin Waldseemüller, is the earliest that can claim to be an index of contemporary geographical knowledge. In 1528 the German geographer Sebastian

Münster appealed to his countrymen to send him maps of their regions "so that all Germany with its villages, towns, trades, etc., may be seen as in a mirror". This was a primitive attempt at a national atlas of composite authorship; and many of the maps received by Münster were printed by him in his edition of Ptolemy (1540) and in his *Cosmographia* (from 1545).

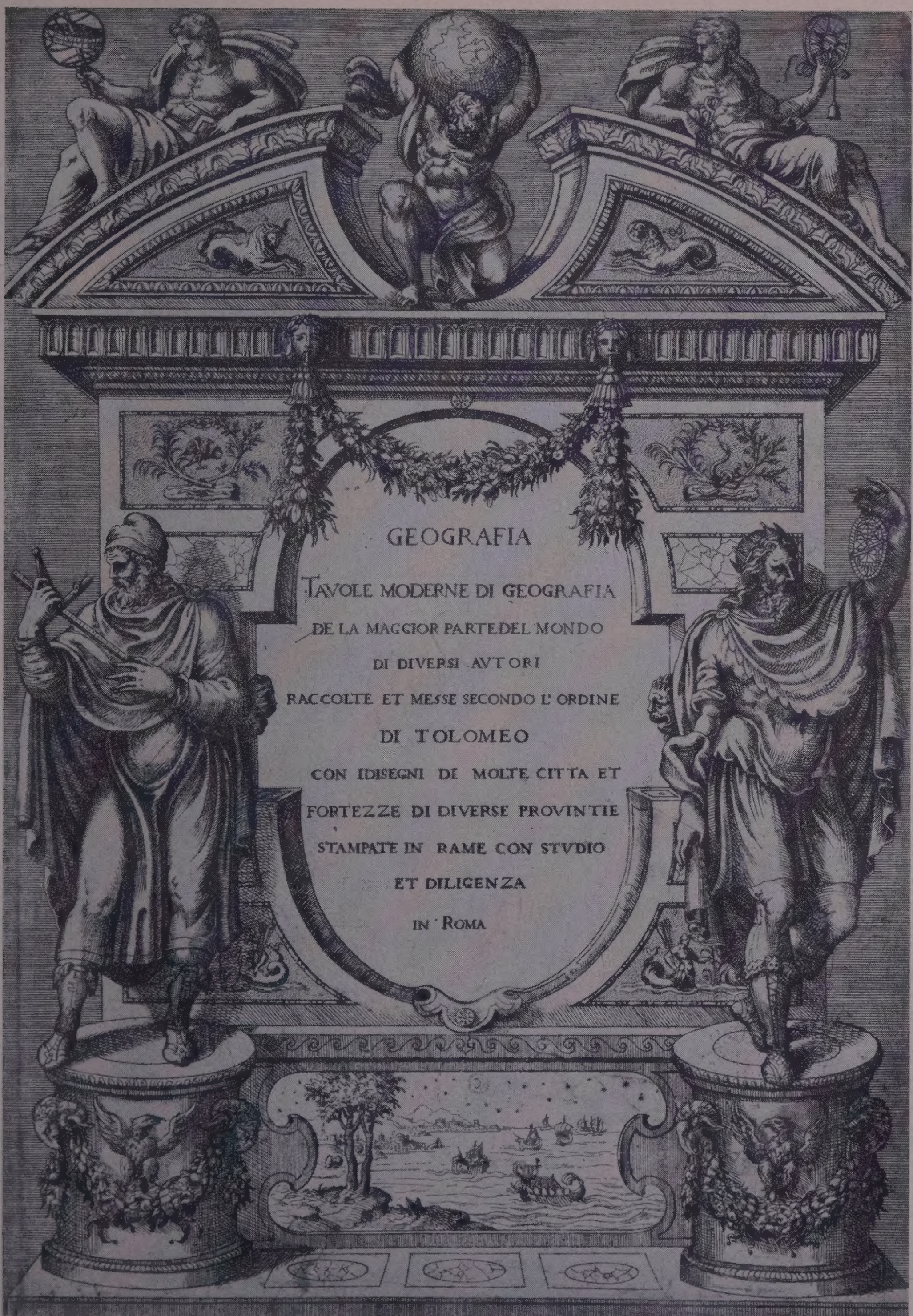
The expansion of the 'modern' section in the Ptolemy editions of the 16th century led by an easy transition to the comprehensive atlas of wholly modern maps. Soon after the middle of the century the map-sellers of Venice and Rome, who then dominated the European market, developed the practice of assembling in a volume, to the order of their customers, collections of "modern maps of the greater part of the world, by diverse authors, gathered and arranged in Ptolemy's order". About seventy collections of this kind are known; made up from maps in stock at the time, they are not uniform in contents. They have been given the name "Lafreri Atlas", from Antonio Lafreri, a Burgundian engraver and map-seller who was in business at Rome from 1544 to 1577 and produced a number of these collections. About 1570 he engraved a title-page for them (Fig. 2); and here we see, for the first time, the figure of the Titan, Atlas, supporting the universe on his shoulders, as a symbol for a collection of maps covering the world.

The origin of Ortelius's celebrated atlas recalls that of the Italian collections. About 1560, at the request of the merchant Aegidius Hooftman, Ortelius (then in business at Antwerp as an illuminator and seller of maps) brought together a set of maps of Europe "not larger than a sheet of paper", that is, of convenient size for handling. This bound volume of thirty-eight maps (about thirty engraved in Rome, the rest in the Netherlands), the prototype of the *Theatrum*, still existed in a somewhat battered condition in 1604, but is now lost. Hooftman's commission brought home to Ortelius the public need for bound sets of maps of uniform size, which would be more convenient in use, less greedy of storage space, and less expensive than the contemporary sheet maps of varied size and style.

Unlike the Italian map-sellers, Ortelius set about the compilation of his atlas for general sale in no haphazard way. He consulted geographers about the most suitable projections, and engravers about problems of reduction; and through his correspondents in many countries he made a critical selection of the best maps available, to be re-engraved by his own artists. When the first edition of the *Theatrum Orbis Terrarum* came from the press of Aegidius Coppens on May 20, 1570, it was therefore a true conspectus of contemporary knowledge; and to it Ortelius prefixed a catalogue of no fewer than eighty-seven cartographers whose work he had consulted or adapted. The folio volume contained seventy maps on fifty-three plates, most of them engraved "by the cunning hand of Frans Hogenberg"; and its title-page bore symbolic figures of the three parts of the Old World (Fig. 3).

Ortelius's friend Mercator wrote with enthusiasm of the *Theatrum*: " . . . you deserve no small praise, for you have selected the best descriptions of each region and have digested them in a single manual, which . . . may be bought for a low price, kept in a small space, and even carried about whither we wish . . . I am certain that this work of yours will always remain saleable." Three more editions were called for in the same year, and before Ortelius's death in 1598 twenty-seven further editions had been printed (from 1579 at the famous Antwerp house of Christopher Plantin), with a steadily increasing number of maps and with text in three European languages besides Latin. The only English edition was published by Ortelius's successor in 1606, and the last edition, with Latin text, in 1612.

Gerard Mercator, the greatest geographer of the Renaissance, whom Ortelius called "the Ptolemy of our day", had met Ortelius at the Frankfort book fair in 1554, and gave him help and encouragement in the preparation of the *Theatrum*. Mercator himself had formulated, and in 1569 described, his scheme for a world atlas; this he conceived as only one part in a grandiose fivefold treatise of the whole creation. The slow progress of Mercator's *Atlas* and his failure to complete it were in the 17th century ascribed to his desire to avoid competition with his friend Ortelius; but they are more easily explained by the sweeping scale of his project, by his method of work, and by the practical difficulties which, as both craftsman and scholar, he encountered. His combination of talents was singled out by a map-engraver of the next generation, Jodocus Hondius, who wrote that Mercator "to his knowledge of geography and chronology added a quality exceedingly rare in scholars—a skill in drawing, engraving and elegant illuminating". Unlike the maps of Ortelius, those of Mercator were compiled, drawn and (for the most part) engraved by himself or by members of his family

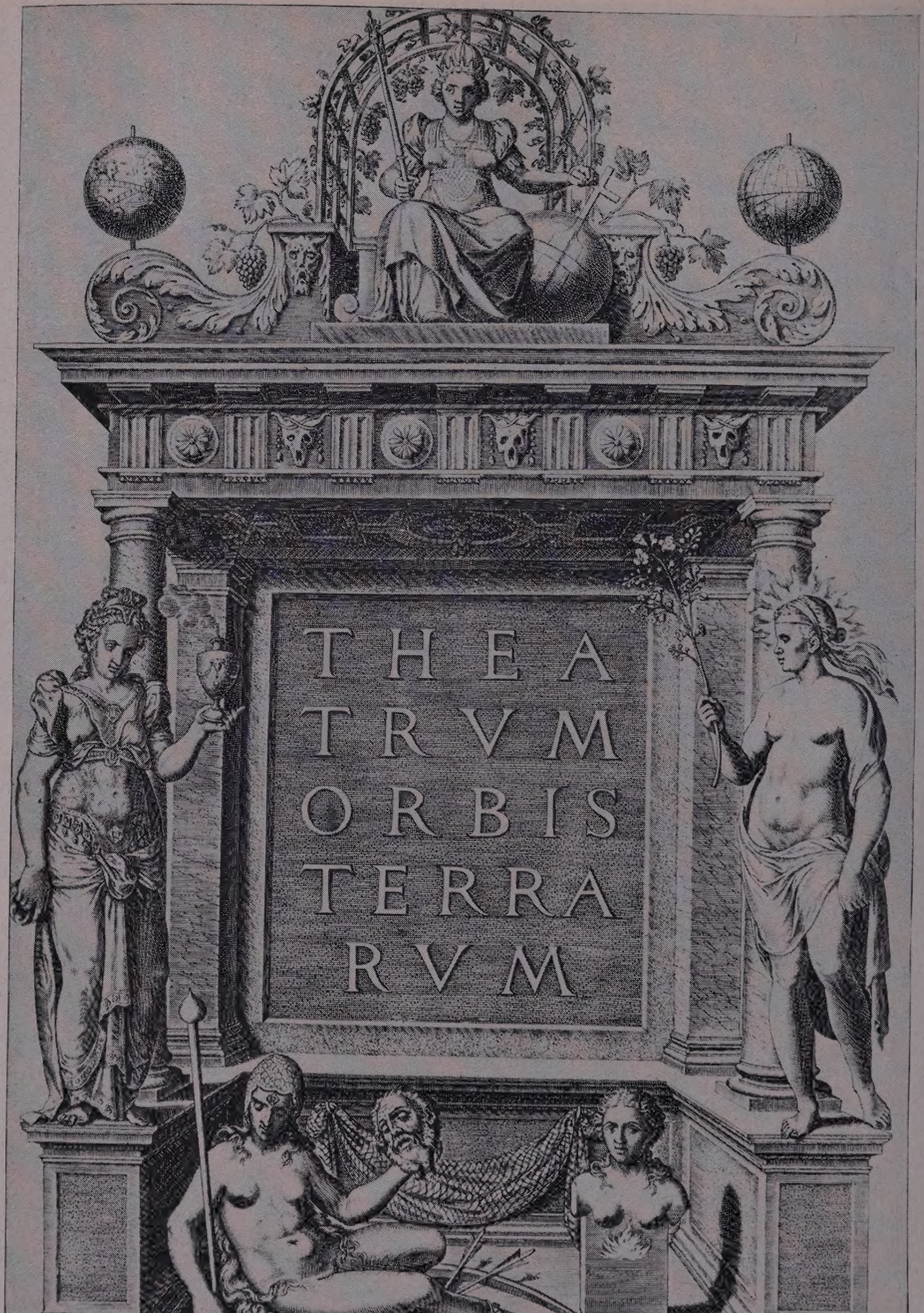


GEOGRAFIA

TAVOLE MODERNE DI GEOGRAFIA
DE LA MAGGIOR PARTEDEL MONDO
DI DIVERSI AVTORI
RACCOLTE ET MESSE SECONDO L' ORDINE
DI TOLOMEO
CON IDISEGNI DI MOLTE CITTA ET
FORTEZZE DI DIVERSE PROVINTIE
STAMPATE IN RAME CON STVDIO
ET DILIGENZA
IN ROMA

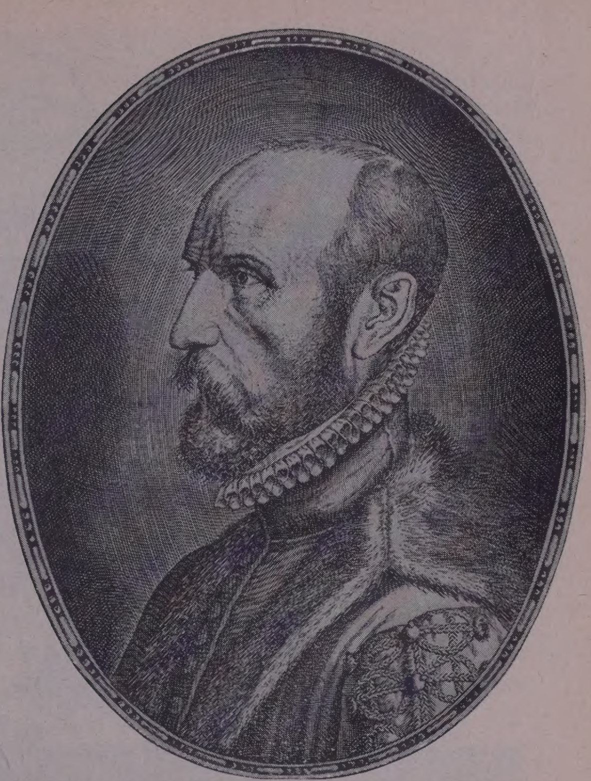
By courtesy of the Royal Geographical Society

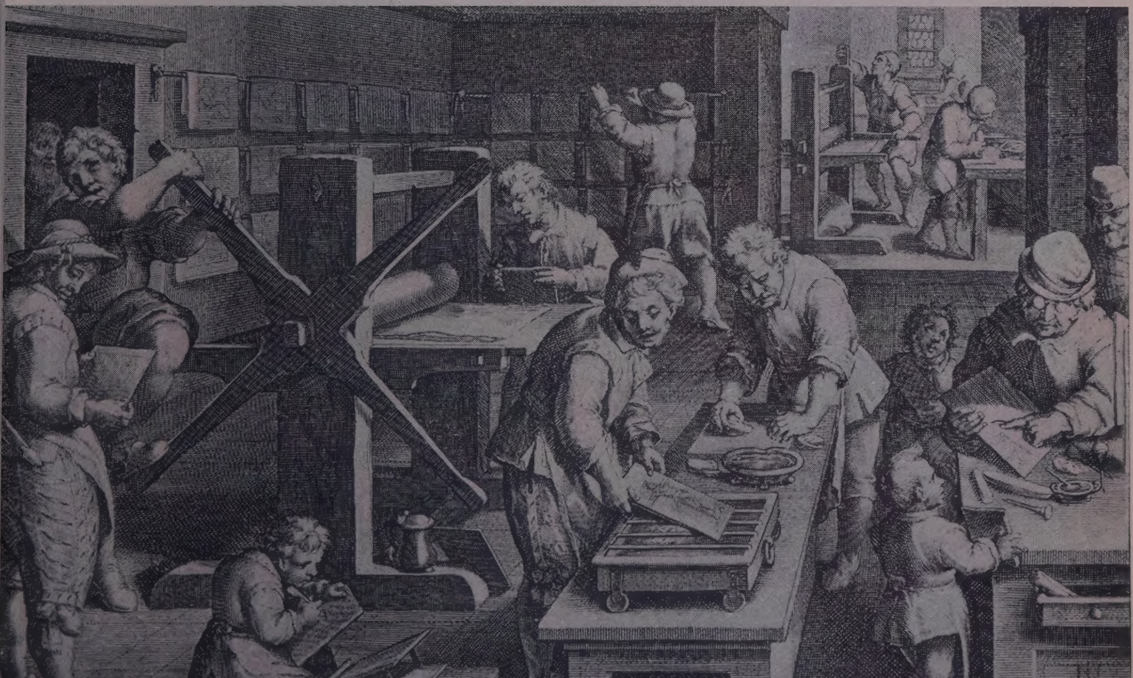
(Fig. 2) Title-page engraved by Antonio Lafreri in Rome, *c.* 1570, for collections of maps published by him

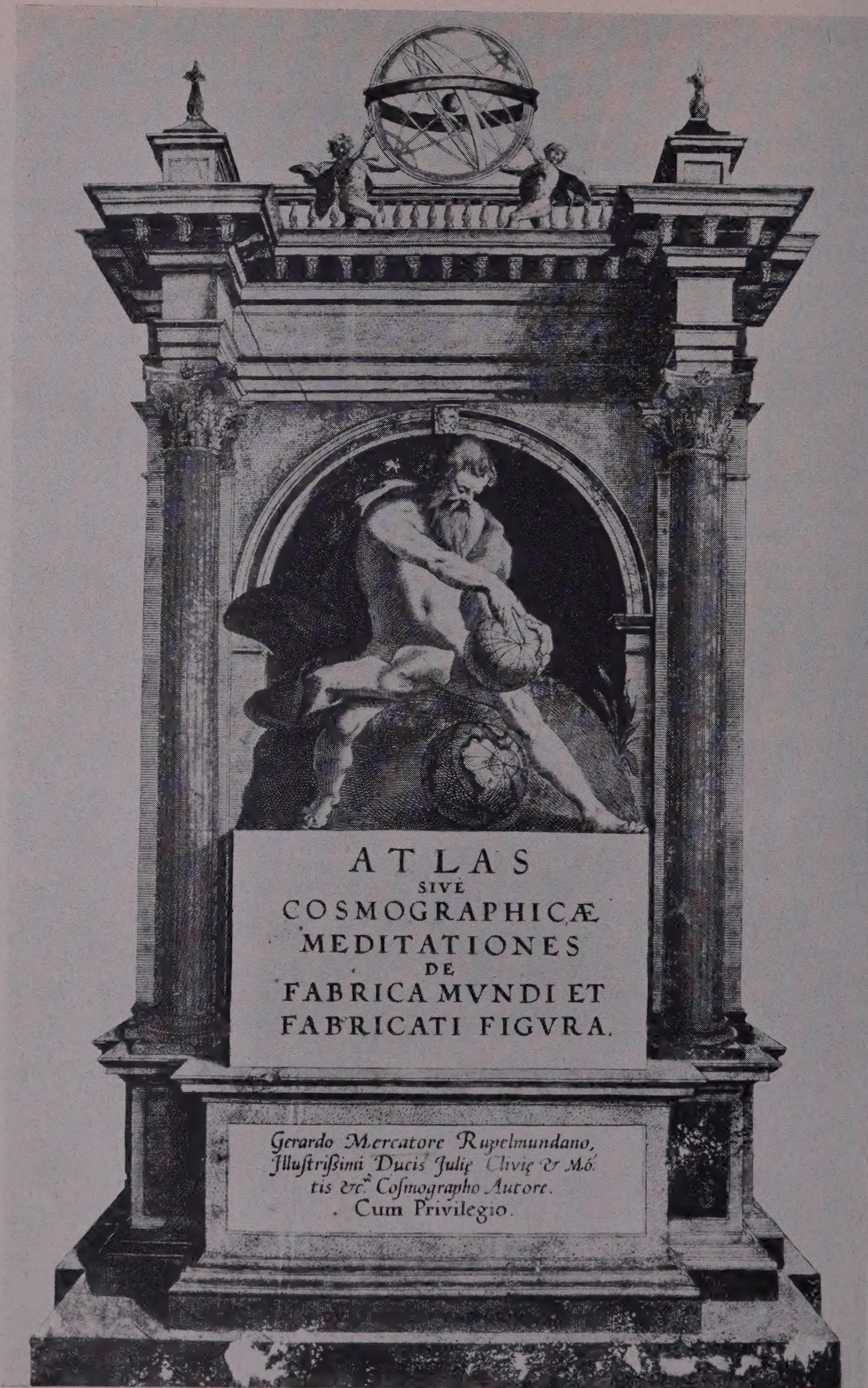


THEA
TRVM
ORBIS
TERRA
RVM

(Fig. 3: *opposite*) The title-page of Abraham Ortelius's *Theatrum Orbis Terrarum*, which was published in 1570. (Fig. 4: *right*) Portrait of Ortelius (1527-98), engraved by Filips Galle; it first appeared in the 1579 edition. (Fig. 5: *below*) A copper-plate printing-shop in the Netherlands, engraved by Joannes Stradanus, *c.* 1580







ATLAS
SIVE
COSMOGRAPHICÆ
MEDITATIONES
DE
FABRICA MVNDI ET
FABRICATI FIGVRA.

Gerardo Mercatore Rupelmundano,
Jlluſtrißimi Ducis Juliç Cliviç & Mõ:
tis &c.ª Coſmographo Autore.
. Cum Privilegio.

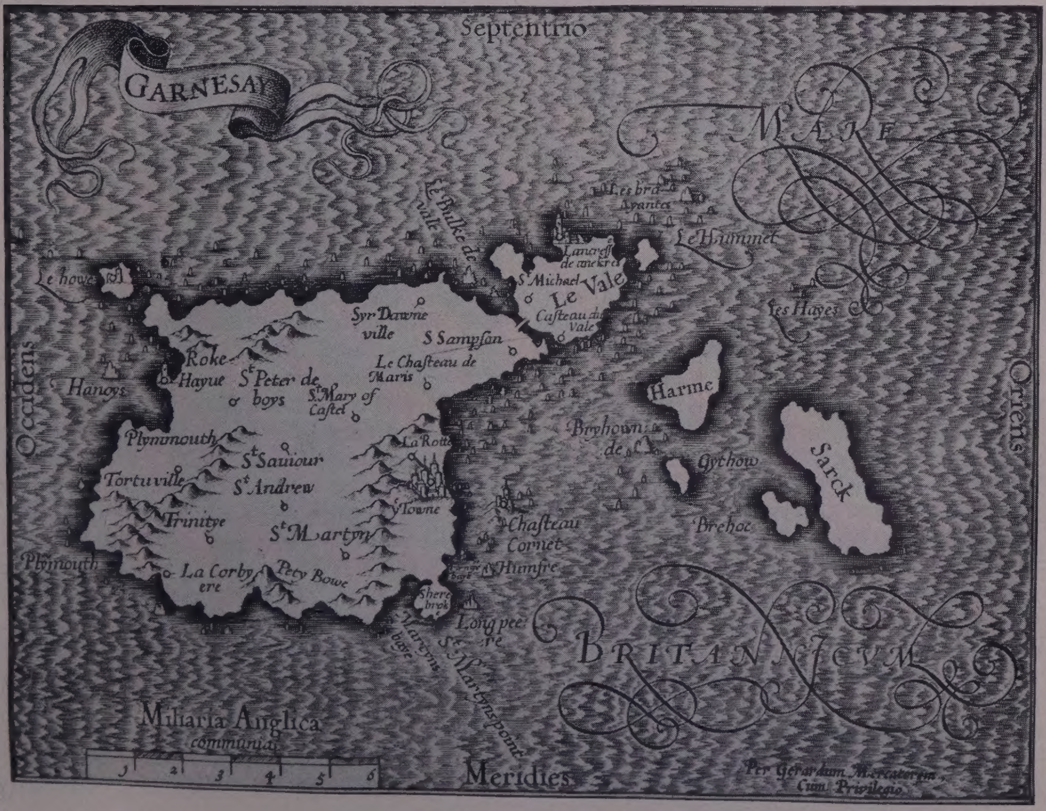
(Fig. 6) The title-page of Mercator's *Atlas*, 1595. (The title may be translated: Atlas, or Meditations of a Cosmographer on the Creation of the World and on the Form of Created Matter)

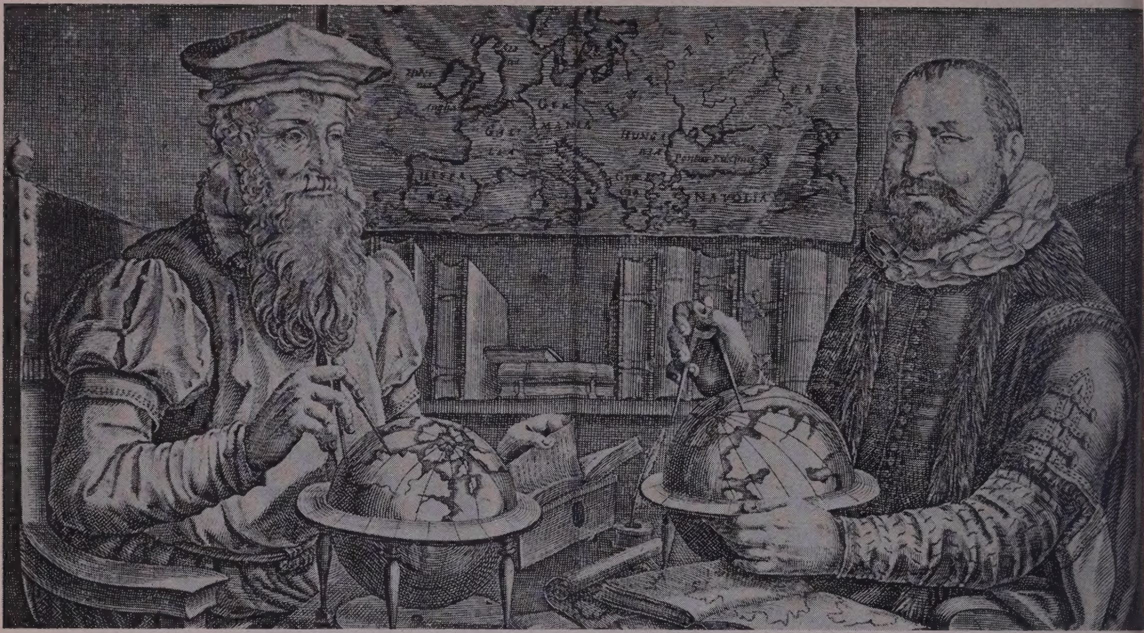
in his Duisburg workshop.

While Ortelius exercised much care in the choice of maps to be copied or reduced by his engravers, little was done to 'edit' them or to bring them into consistency with other maps in the *Theatrum*. Mercator, on the other hand, envisaged each sheet of his *Atlas* as a section of a whole world map, ensured that it was correctly placed in relation to the others by the graduation in latitude and longitude, and submitted every detail to rigorous criticism before admitting it (Fig. 7). This process gives the maps from his hand an individual character, a fineness of execution, and an air of authority which those of the *Theatrum* often lack, and which (as we shall see) account for the much longer life enjoyed by Mercator's plates; but Mercator's method of work called for more time than that of Ortelius.

In Mercator's cosmographical scheme, geography formed one of the five divisions and was again subdivided into three parts: modern maps, Ptolemy, and ancient geography. The third of these remained unaccomplished; the second, Mercator's edition of the *Geographia* with the maps re-engraved, was completed and published in 1578; and the modern atlas was never finished, although two parts of it appeared before Mercator's death in 1594 and a third, edited by his son Rumold, posthumously. In 1585 the maps of "Gallia" (France, Switzerland, the Netherlands) and "Germania" were printed at Mercator's press at Duisburg, each with its own title-page and so forming a national atlas; and in 1589 followed those of "Italia, Slavonia et Graecia". Finally, in 1595 Rumold Mercator brought out a great folio volume, the title of which indicates the broad sweep of his father's cosmographical thought (Fig. 6); the first part contains the text of Mercator's essay on the creation of the world, the second the 107 maps. The maps now added comprised those of the British Isles and of Northern and Eastern Europe, with maps of the world and the four continents by Mercator's son and grandsons: The regional maps of Spain and Portugal and of countries outside Europe were never executed.

(Fig. 7) Mercator's map of Guernsey, in the *Atlas* of 1595





(Fig. 8) Portraits of Gerard Mercator (1512-94) and Jodocus Hondius (1563-1611), published in Hondius's first edition of the *Atlas*, 1606

The magnificent torso of Mercator's work not only introduced the word Atlas into common currency, but also provided the model and framework for the great undertakings of this kind projected in the next century.

THE CENTURY OF ATLASES

The atlas was to become the dominant cartographic form of the 17th century, and its history exemplifies both the supplanting of Antwerp by Amsterdam as the principal centre of map production and the commanding position achieved by the Dutch in the international map trade. The Amsterdam houses owed their success to their control of capital, derived largely from a strong and prosperous home market, and to their highly developed workshop organization. Thus the maps of John Speed's *Theatre of the Empire of Great Britain* (published 1611-12), the earliest large-scale map-publishing venture in this country, were sent to be engraved in the Amsterdam shop of Jodocus Hondius. Hondius had already, in 1604, purchased the plates of Mercator's *Atlas*, and its expansion and frequent republication were to be the staple of his firm and of its successors in business for three-quarters of a century. In the first edition issued by him, in 1606, Hondius added thirty-six maps to those of Mercator; and over the successive imprints of his son Henricus Hondius and his son-in-law Jan Jansson the *Atlas Novus*, as it came to be called, grew to four volumes (with over 350 maps) by 1646, and to six volumes (with nearly 500 maps) by 1658, with text in five languages; and finally to ten or eleven volumes.

This expansion was largely stimulated by the competition of a powerful rival. The scholar-cartographer Willem Jansz. Blaeu entered the field of atlas-publication, late but effectively, with his *Atlantis Appendix*, which appeared in 1630 with sixty maps (including thirty-seven plates purchased from Henricus Hondius!). This was followed in 1631 by Blaeu's *Appendix Theatri A. Ortelii et Atlantis G. Mercatoris*, with ninety-nine maps; by 1634 the collection was styled *Novus Atlas*; and in 1635 it was extended to a two-volume work of 207 maps under the title—still recalling its two great predecessors—*Theatrum Orbis Terrarum, sive Atlas Novus*. After Blaeu's death in 1637, his sons gradually enlarged the *Atlas Novus* in step with—and often in advance of—the Hondius-Jansson publication. By 1655 it had reached six volumes with over 400 maps, and in 1662 came the magnificent *Atlas Maior sive Cosmographia Blaviana*, of eleven volumes and nearly 600 maps (Figs. 9, 11).

Like Ortelius, but with less discrimination, the Hondiuses and Jansson copied into their atlas such maps by other cartographers as they could acquire—sometimes even those of Blaeu—to depict regions still unrepresented. The Blaeus, father and son, were their superiors both in selection and in presentation of their materials. Their official appointment as hydrographers to the Dutch East India Company and to the States-General placed at their disposal much first-hand cartographic work, some of it secret; and their enterprise in bringing regional surveys into print is illustrated by their publication of the first atlas of Scotland (in 1655, as vol. V of the *Atlas Novus*), from Timothy Pont's manuscript surveys, and of the atlas of China by the Jesuit father Martino Martini (as vol. VI of the *Atlas Novus*, in the same year). As a scientific cartographer, trained by the Danish astronomer Tycho Brahe, the elder Blaeu was fastidious in his choice of projections and in setting out the geographical apparatus of his maps. Like Mercator, Blaeu and his sons were accomplished craftsmen, who controlled every stage in the production of their maps and books. A German visitor to Amsterdam in 1663 described "the far-famed printing house of Johan Blaeu", with its "nine type presses, named after the nine Muses, six presses for copper-plate printing, and type foundry"; storage cases for the plates "from which the atlases . . . and other choice books are printed"; and rooms for washing type, drying sheets, and proof-reading. On the same premises were carried on the drawing, engraving and colouring of maps, the making of fine paper with Blaeu's own mark, and the binding. The superb craftsmanship of the house is apparent in its vellum-bound atlases, often stamped with the arms of the collector for whom they were prepared and illuminated (Fig. 11).

In the second half of the 17th century other family firms of Amsterdam—Visscher, De Wit, Danckerts—published world atlases, none on the ambitious scale of Jansson and Blaeu; and the plates of the older businesses were dispersed among such firms after the destruction of Blaeu's printing-house by fire in 1672 and the sale of Jansson's stock by auction in 1694.

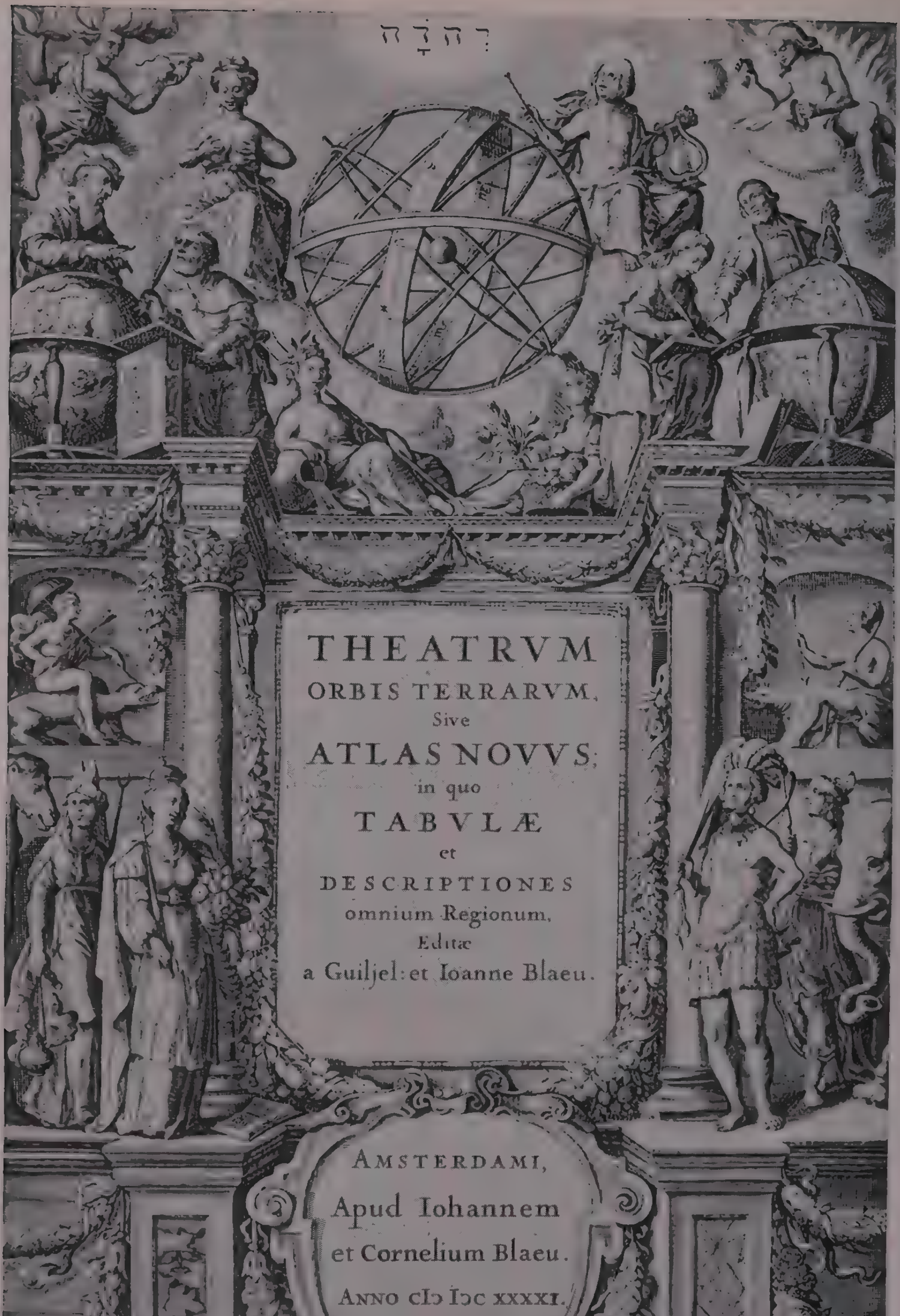
In the atlases of this period the engraved maps were commonly backed by text, although separate impressions of the maps with blank backs were also on sale. The conflicting demands of printing in one volume from type, which must be quickly distributed, and from copper plates, from which (to reduce wear) no more impressions should be taken than were needed for immediate sale, were neatly reconciled. A very large number of sheets were printed from type on the text side; the type was distributed; and the maps were added only to so many sheets as were called for by each successive edition of the atlas, in which the text was therefore usually a reissue and the maps new impressions. The plates could be, and were occasionally, revised, and these alterations are sometimes the only evidence for dating an edition when (as often) the engraved title-page date is uncorrected.

Regional cartography in atlas form had been initiated in the 16th century, and national atlases of many countries appeared in the 17th, either separately or incorporated in the larger world atlases. By the end of the century map-publishers in other countries had established themselves with sufficient substance and commercial organization to produce world atlases modelled on the Dutch prototypes. In France, particularly, an independent map industry developed as a productive unit, enjoying royal patronage, under the direction (in turn) of Nicolas Sanson of Abbeville, his sons, and A. H. Jaillot. Sanson's maps were first collected into atlases about 1645, and were re-engraved by Jaillot in a series of splendidly decorated world atlases from 1689.

In Italy, at the end of the century, there appeared the isolated but commanding figure of the Franciscan V. M. Coronelli, Cosmographer to the Republic of Venice (Fig. 12). Coronelli combined sound geographical scholarship and judgement with a taste for baroque decoration and grandiose design. These qualities found expression both in his globes, which ranged from two inches to fifteen feet in diameter, and in his immense *Atlante Veneto* in twelve volumes published in 1697.

SEA-ATLASES

The earliest modern sea-atlas to be printed was *De Spiegel der Zeevaerdt*, by Lucas Jansz. Waghenaer of Enkhuizen, the first part of which came from Plantin's press at Antwerp in 1584 (Fig. 13). Here, as in the manuscript pilot-books from which it descended, but for the first time on engraved charts, the seaman found many features necessary to navigation laid down by conventions still in use today—soundings, reefs and other hazards, leading lines and landmarks, channels and buoys. Since the charts were printed, the danger of copyist's errors was greatly reduced and the pilot could use them with the more confidence. For over a century such sea-

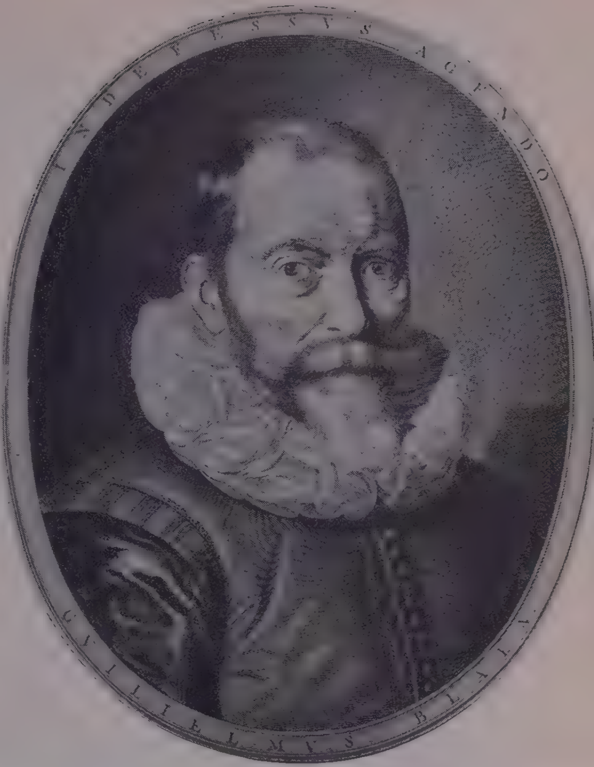


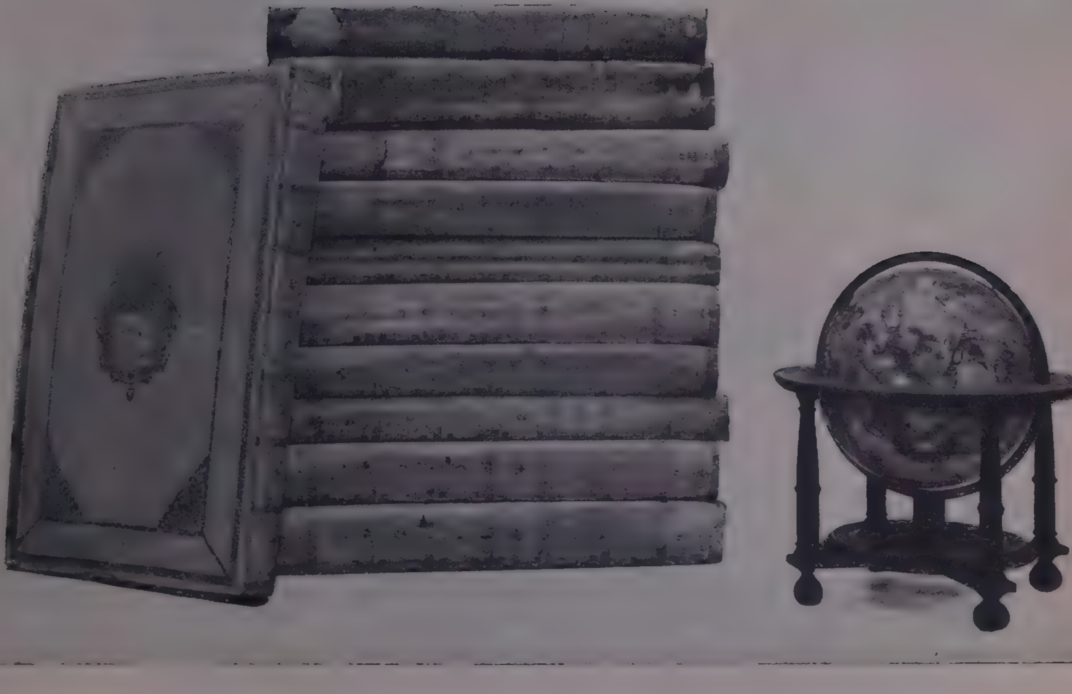
יְהוָה

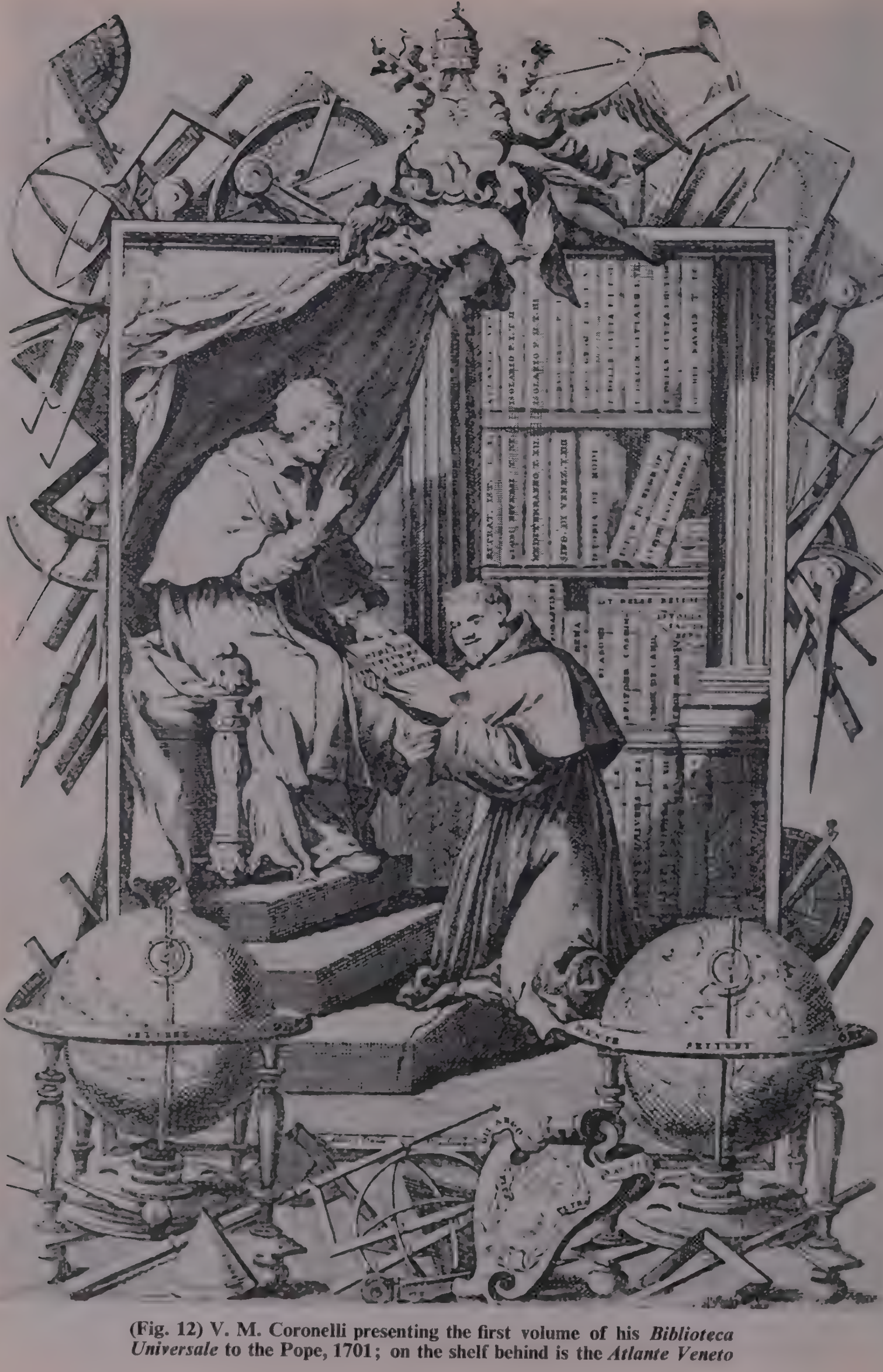
THEATRVM
ORBIS TERRARVM,
Sive
ATLAS NOVVS;
in quo
TABVLÆ
et
DESCRIPTIONES
omnium Regionum,
Editæ
a Guiljel: et Ioanne Blaeu.

AMSTERDAMI,
Apud Iohannem
et Cornelium Blaeu.
ANNO CIↃ IↃC XXXXI.

(Fig. 9: *opposite*) Engraved title-page used by W. J. Blaeu and his sons in editions of their *Atlas Novus* from 1635. (Left and right, figures symbolizing the four continents; above, an armillary sphere constructed on Ptolemy's system.) (Fig. 10: *right*) Portrait of Willem Jansz. Blaeu (1571-1638), engraved by Jeremias Falck of Danzig. (Fig. 11: *below*) The *Atlas Maior sive Cosmographia Blaviana* of 1662, in eleven volumes, vellum-bound and gilt-tooled; with W. J. Blaeu's celestial globe of 1602, 9¼ inches in diameter

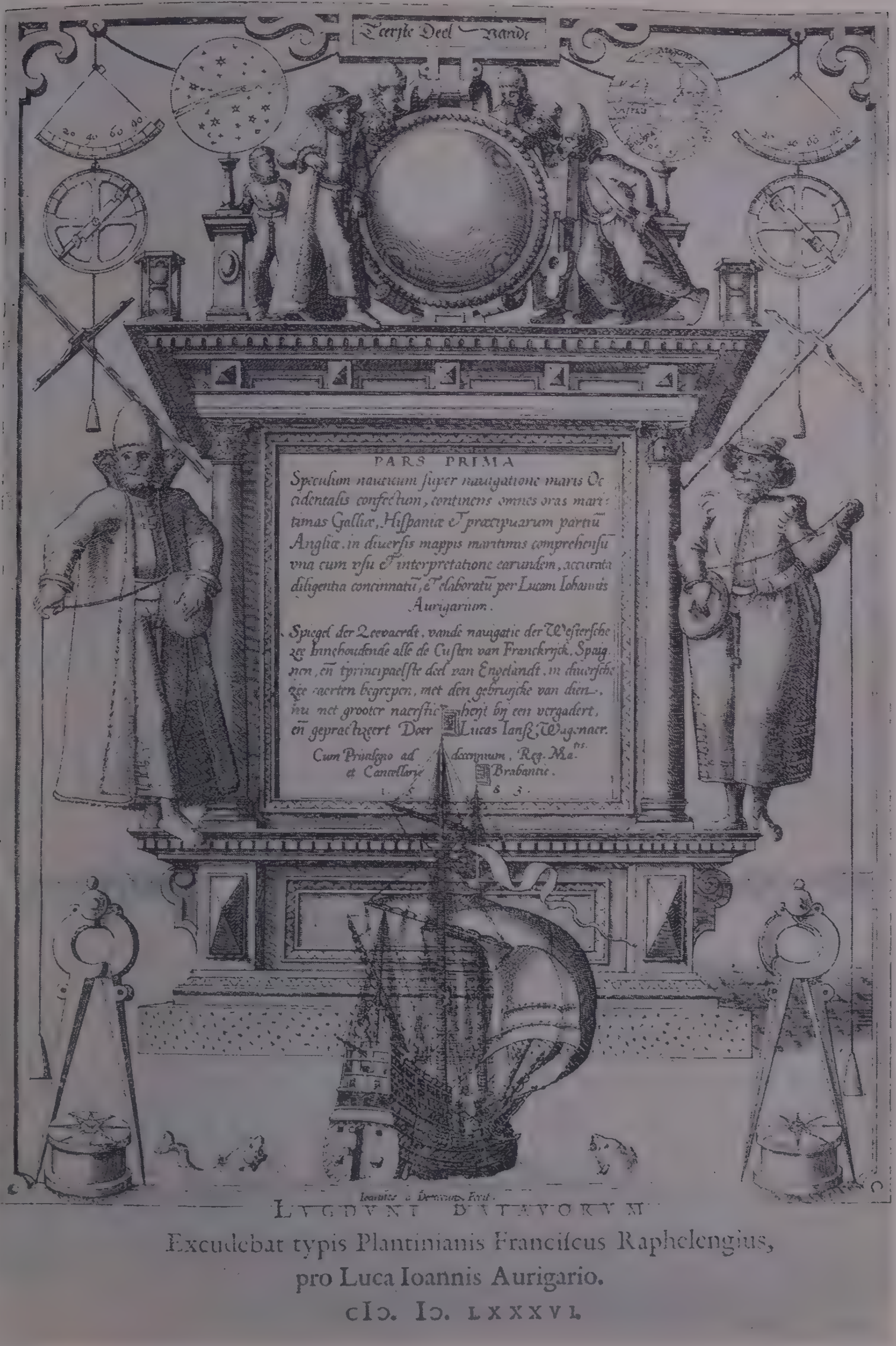





ISOLARIO P. I. T. II
ISOLARIO P. II. T. III
ISTORIA DI VENEZ. T. VIII
ISTORIA DE MODI

(Fig. 12) V. M. Coronelli presenting the first volume of his *Biblioteca Universale* to the Pope, 1701; on the shelf behind is the *Atlante Veneto*

(Fig. 13) The title-page of Part I of Waghenaer's sea-atlas *Spiegel der Zeevaerdt*, Latin edition, 1586; with instruments for navigation represented in the border



Teerſte Deel vande

PARS PRIMA

Speculum nauticum ſuper nauigatione maris Occidentalis confectum, continens omnes oras maritimas Galliæ, Hiſpaniæ & præcipuarum partiū Angliæ. in diuerſis mappis maritimis comprehenſū vna cum vſu & interpretatione earundem, accurata diligentia concinnatū, & elaboratū per Lucam Iohannis Aurigarium.

Spiegel der Zeevaerdt, vande nauigatie der Weſterſche zee Innehoudende alle de Cuſten van Franckrijck, Spaignen, ē tprincipaelſte deel van Engelandt. in diuerſche zee caerten begrepen, met den gebruijcke van dien, nu met grooter naerſticheijt bij een vergadert, ē gepractizeert Door Lucas Ianſz. Wagenaer.

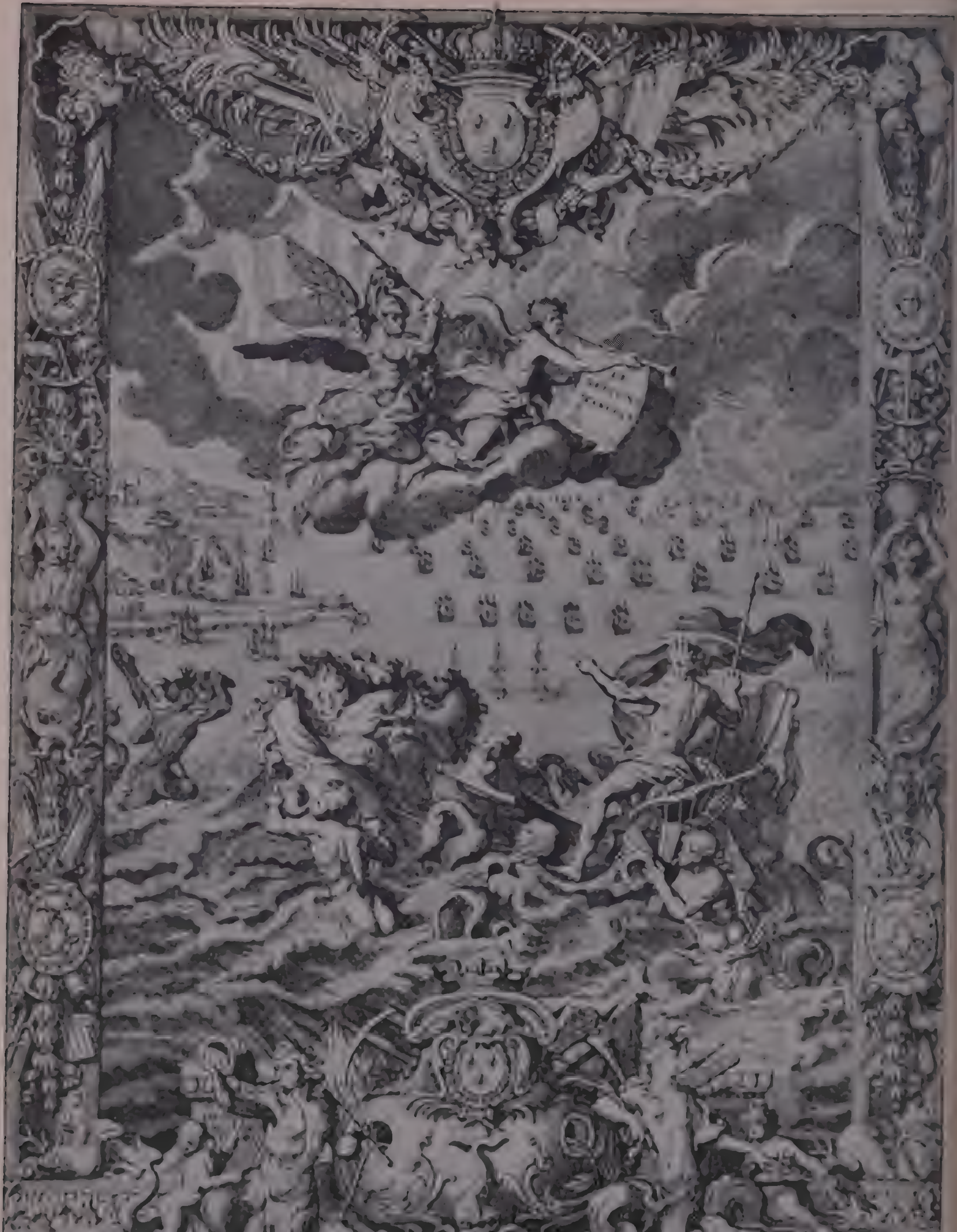
Cum Priuilegio ad decennium, Reg. Ma^{tis}.
et Cancellariæ Brabantiæ.

1 5 8 3.

Ioannes a Deutecum Fecit.

LVGDVNI BATAVORVM

Excudebat typis Plantinianis Franciſcus Raphelengius,
pro Luca Ioannis Aurigario.
cIↃ. IↃ. LXXXVI.



(Fig. 14) The title-page of *Le Neptune François* engraved by Jan van Vianen, 1693 atlases accompanied by sailing directions were familiarly known, from the name of their progenitor, as "waggoners".

During the 17th century, when Dutch maritime activity reached its highest level, the Netherlands led the field in hydrography and chartwork. Up to the middle of the century Blaeu's two sea-atlases, *Het Licht der Zeevaert* (1608) and *De Zeespiegel* (1623), met with little competition, but thereafter many handsome works of this kind, with titles as flamboyant as the decoration of their title-pages, were produced by rival firms vying for the native and foreign markets. Such atlases were (to give them the titles of their English editions) *The Upright Fyrie Colomne* of J. A. Colom, *The Sea Atlas or the Watter-World* of P. Goos, and *The Lightning Colomne or Sea Mirror* of T. Jacobsz.; and their technique of chart construction and drawing was conservative, showing little advance on Waghenaer. Yet Blaeu had occasionally made use of the Mercator projection; and the first sea-atlas with charts drawn entirely on this projection, the *Arcano del Mare* of the Englishman Sir Robert Dudley, had been engraved and published at Florence in 1646-7.

The reformation of cartography in the late 17th century was the work of French geodesists directed by the Académie Royale des Sciences. After the foundation of the Paris Observatory in 1671, under J. D. Cassini, French scientists were active in determining the latitude and longitude of places by astronomical methods. In the great sea-atlas *Le Neptune François*, published at Paris in 1693, the coasts of Western Europe were laid down from accurately fixed positions supplemented by a thorough land survey; and its charts, drawn on the Mercator projection, were all graduated in latitude and longitude (Fig. 14). This marked an epoch in hydrographic publication; and its pattern was followed by the official French charts gathered in 1756 in the atlas *L'Hydrographie Française*.

In the 18th century, an age of intense activity in seaborne commerce and warfare and in the publication of maps and charts, a multitude of "Pilots" and "Neptunes" delineated the coasts and navigations (or ocean routes) of the world. The noblest of these in presentation was *The Atlantic Neptune* (1777-81), the first cartographic work to be published by the Admiralty; its charts, superbly drawn by J. F. W. Desbarres, covered 1000 miles of the North American coasts from British surveys. Atlases of charts were also published with numerous accounts of voyages of discovery, notably those of Captain Cook, the most accomplished hydrographer of his day.

TOWARDS THE MODERN ATLAS

By the beginning of the 19th century the seeds of the modern atlas had already been sown. New techniques of observation and analysis introduced a wealth of data which, with improved methods of cartographic representation, enabled the mapmaker to record, more precisely than ever before, not only the topography of land surfaces but also the materials of special sciences in their geographical relationships. The typical products of the new age were the general atlases, such as Stieler's *Hand-Atlas*, the successive editions of which (from 1817 to 1930) formed an index to the current state of world cartography, and the special or thematic atlas, exemplified in the *Physikalischer Atlas* of Heinrich Berghaus, completed in 1848. These are the prototypes of the atlases of today.

Plantin's printing mark, 1593

Colour in Mapmaking

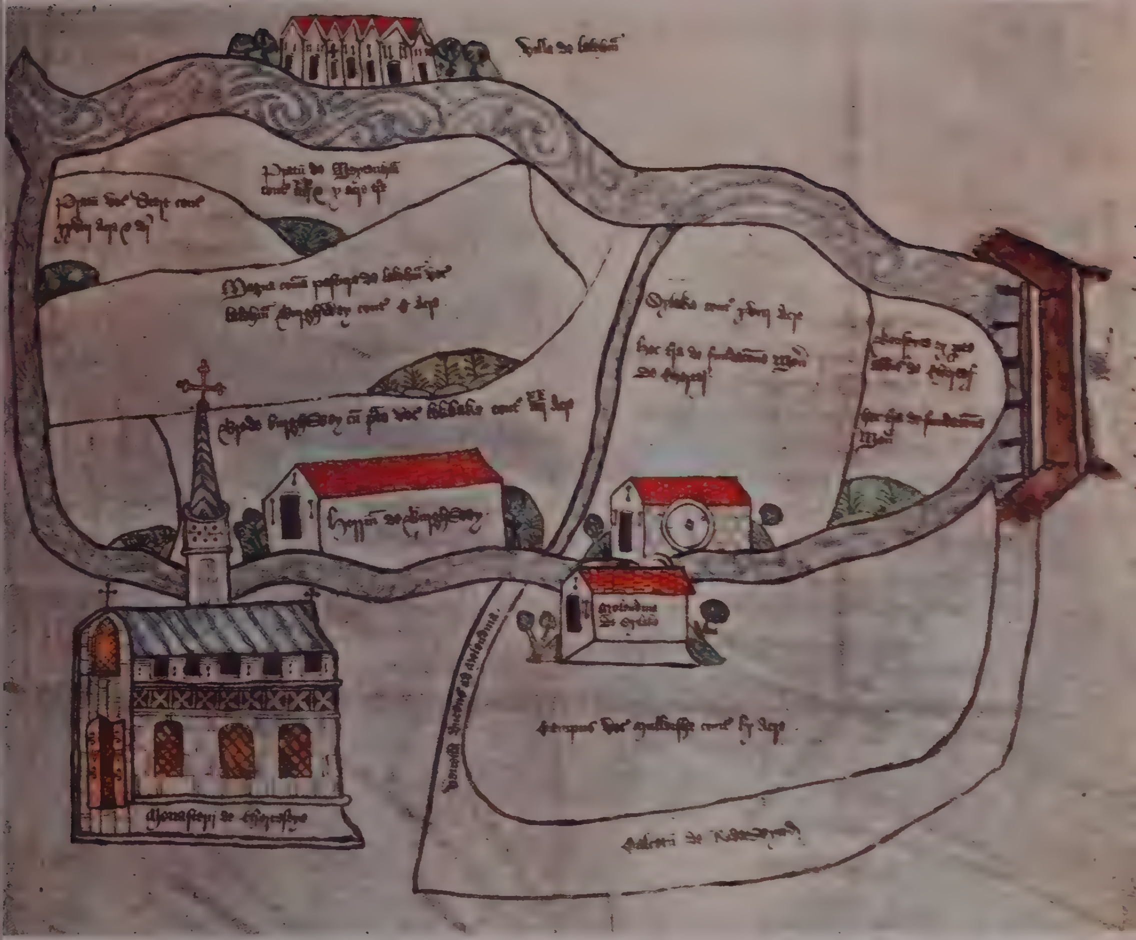
by R. A. SKELTON

FROM the late Middle Ages mapmakers have used colour to enhance the decorative quality of their work. To begin with, they adopted the pictorial technique exercised in the miniatures of illuminated manuscripts; place names and legends were rubricated, as in written texts, and mediaeval world-maps and sea-charts did not lack "convenient spare and voide places" to be filled by gaily hued vignettes of foreign princes, incidents from myth or legend, fabulous beasts, ships and sea-monsters. The specialized apparatus or "complements" of a map provided further opportunities for coloured ornament. Countries and cities were distinguished by brightly blazoned coats of arms or standards; wind-heads and compass-roses, scale and dividers, the "margent or square stick of degrees" and the "compartiments" (cartouches or formal panels)—all these could be tricked out by the artist's invention with decorative detail in vivid colouring. The limner and the cartographer were closely allied; and by the mid-16th century the colouring of maps had become an independent trade, recognized by the artists' guilds and followed, in his early years, by Ortelius. Coloured copies of his *Theatrum* were offered for sale by Ortelius at double the price of plain copies. The decorative use of colour reached its most sophisticated form in manuscript maps and charts of the 16th and 17th centuries, particularly in those drawn for distinguished patrons (Figs. 3, 4, 6); but from the elaborate ornamentation of engraved maps also, colours blazed in brilliant variety. The naturalistic ornament of 17th- and 18th-century maps—trophies, cornucopias, ships, figures, ribbons, fruit and flowers—was "coloured according to the nature of it" (as a writer of 1701 recommended), e.g. crowns with yellow, flesh with tincture of cochineal in water, the smoke of ships' guns "with very thin bice" (Figs. 4, 6, 7, 9). All these were water-colours (occasionally body-colour) applied by hand. Some experiments in two- or three-colour printing of woodcut maps, based on the practice of text-printers, had been made in the early 16th century (Fig. 2); but the serious history of colour-printing of maps does not begin until the 19th century.

The functional use of colour to supplement and distinguish the mapmaker's symbols is at least as old as its decorative use, and has outlived it. The practice of colouring each feature represented in a map "according to the nature of it" may go back to the Romans and is found in mediaeval maps of all kinds. In the world-maps of Ebstorf and Hereford, both of the 13th century, water features are coloured blue and the roofs of buildings (reflecting the colour of tiles) red. The maps of Great Britain drawn by Matthew Paris about 1250 and by an anonymous cartographer a century later (the so-called "Gough map") show the sea in green, rivers and lakes in blue or green, and the symbols for woodland in a darker green; and in the Gough map roads are drawn in red. The colour conventions established in such early maps and derived from the imitation of nature have persisted throughout the history of cartography; and today, as six or seven centuries ago, the mapmaker employs blue for water features, green for woodland, red for human settlements, and brown or red for roads.

To early printed maps colour was added sparingly. It is a matter of taste whether the graceful linework of a skilled engraver on copper is improved by colour, and the finely engraved Italian maps of the 16th century were seldom coloured. But by the end of the century the Netherlands had supplanted Italy as the principal map-producing country, and the Dutch cartographers who held the field for over a hundred years showed a lively appreciation of the power of colour to arrest and direct the map-reader's eye. Their representation of human geography on the map, supported by colour, was varied and expressive (Fig. 8). Settlements, now drawn in plan, were still tile-red; and tints were used to differentiate types of land use and cultivation—a practice long followed in the large-scale plans of estate-surveyors, who commonly coloured pasture green and arable brown. Political and administrative boundaries were emphasized by colour, either applied as a thin wash over a whole territory or as a band outlining the boundary symbol (Figs. 5, 8).

In the printed cartography of the 18th century colour was still generously employed in the

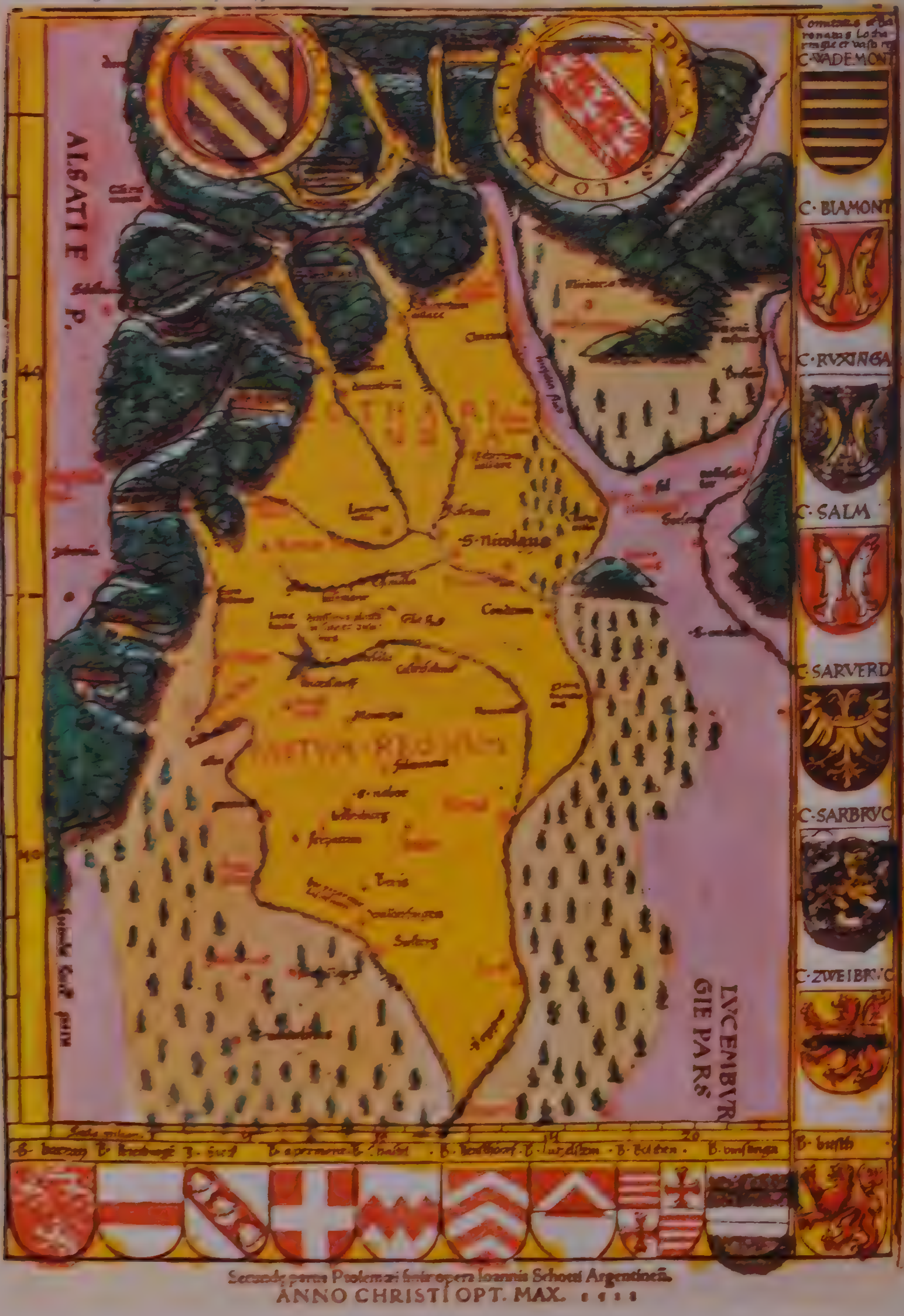


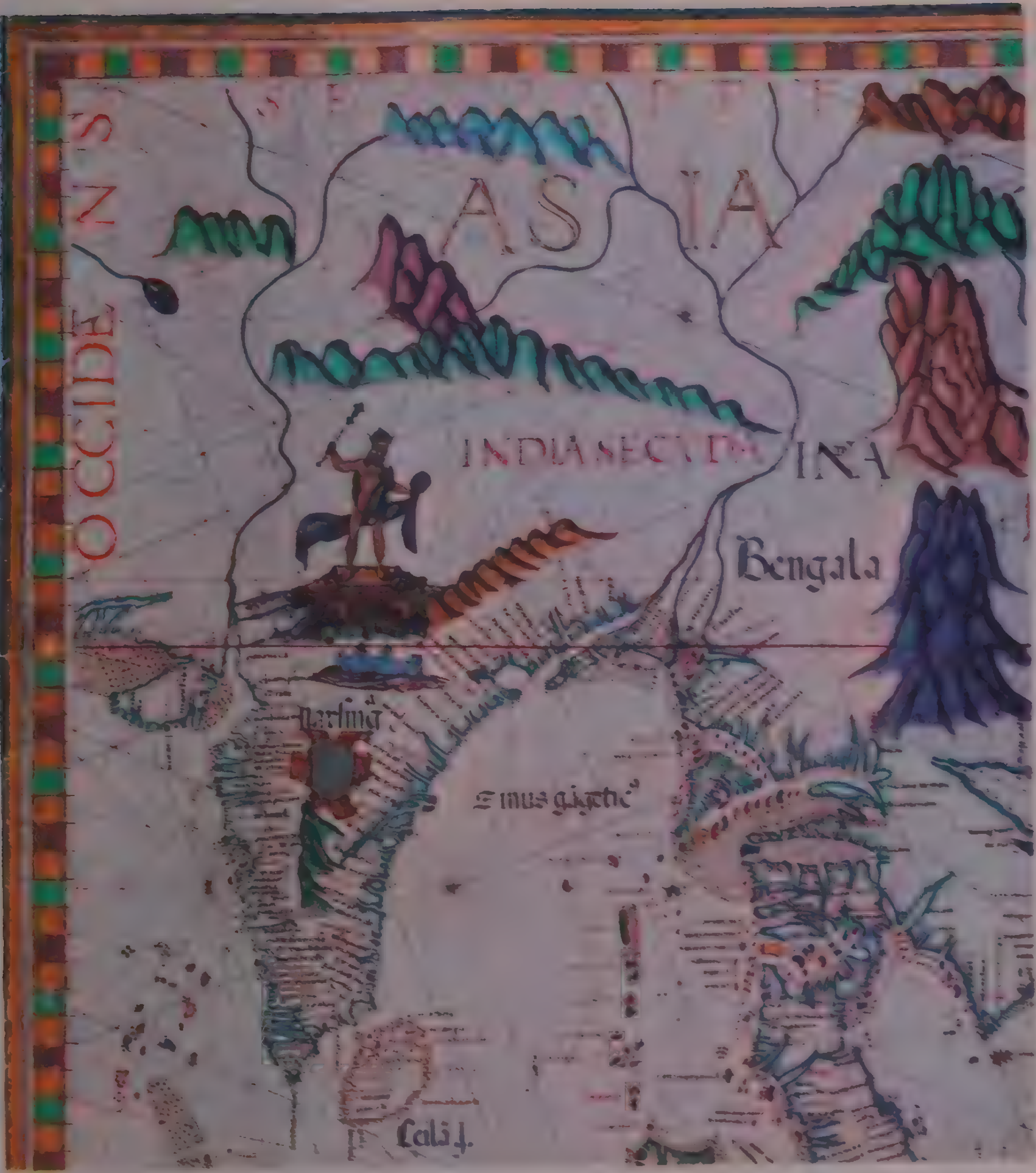
By permission of the Public Record Office

(Fig. 1) The plan of the demesne lands of the Benedictine Abbey of Chertsey, drawn about 1432 and preserved in the cartulary of the Abbey, shows the characteristic mediaeval use of colour, at once naturalistic and decorative, within the map itself. The plan is designed to display the extent and importance of the Abbey's estate, with the aid of coloured pictorial symbols, which are placed with more respect for emphasis than for correct location. The River Thames flows across the top of the plan and, like its tributary streams, is coloured blue with a scrollwork pattern. On its north bank, fringed by willows, lies the town of Laleham, represented by buildings with buff walls and red roofs. On the right a road crosses the river by a brown-coloured bridge. Prominent in the foreground (though misplaced) is the Abbey Church, carefully drawn and coloured, the roofs, which were presumably of lead, being blue-grey. Beside the stream the artist shows the Abbey barn and two mills, all with red-tiled roofs; and the osier beds in the meadows are dark green

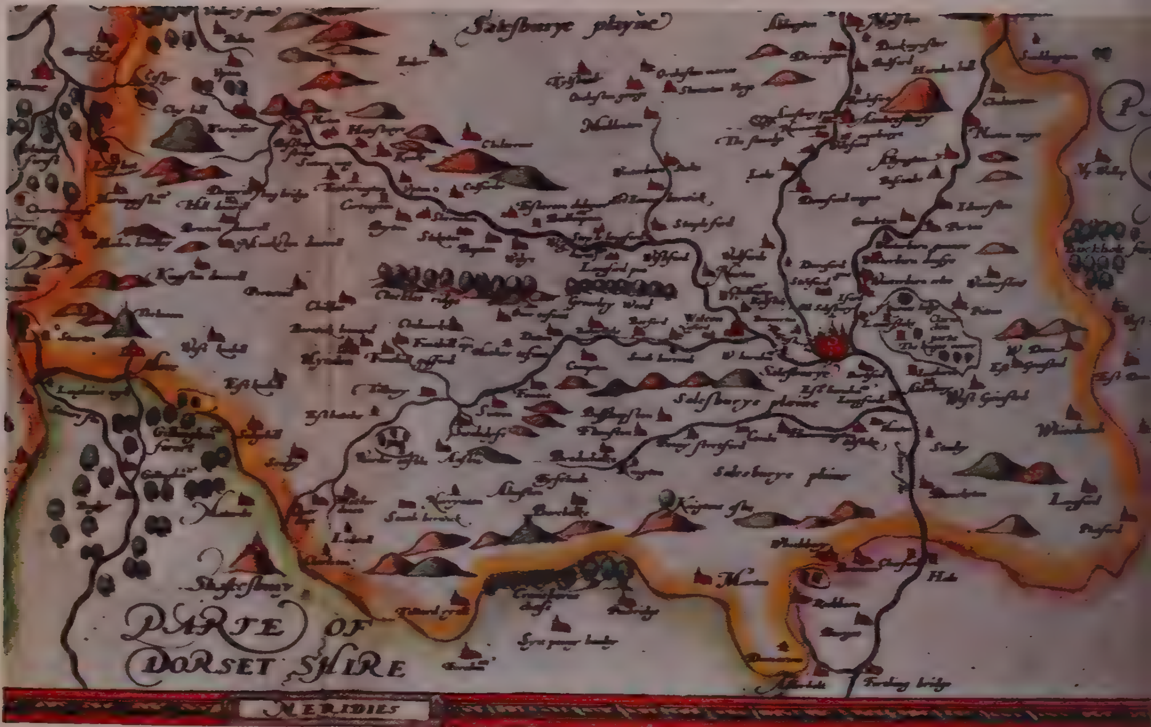
(Fig. 2) Early three-colour printing: the woodcut map of Lorraine in the edition of Ptolemy's *Geographia* printed at Strassburg in 1513. The map and borders are in black; names and town-symbols in red; hills in brown; armorial details in red and brown. Other colours are added by wash

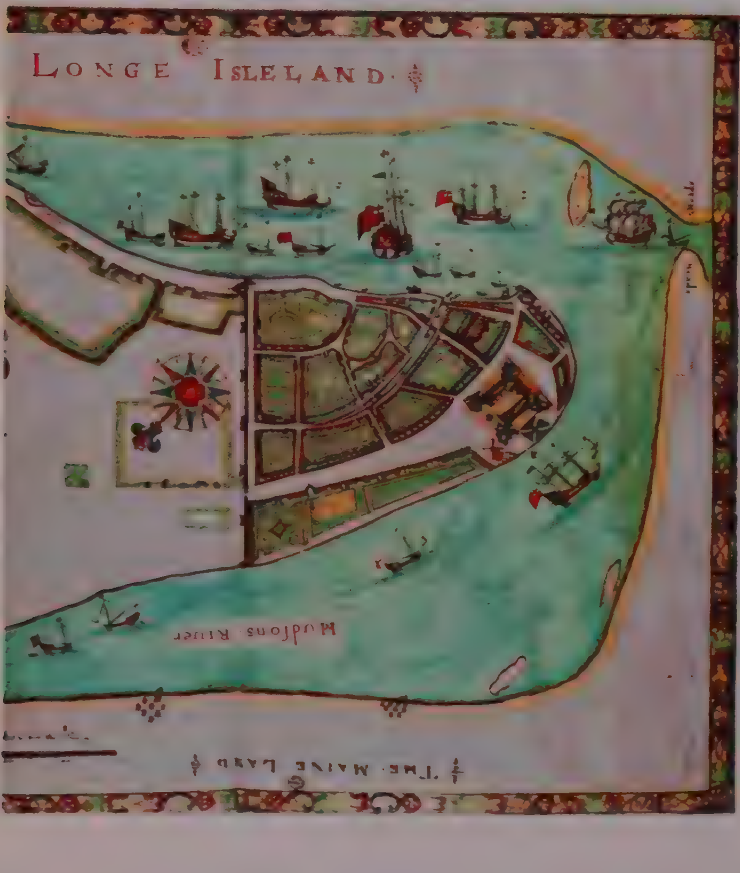
ll remaining illustrations, except one, from the British Museum



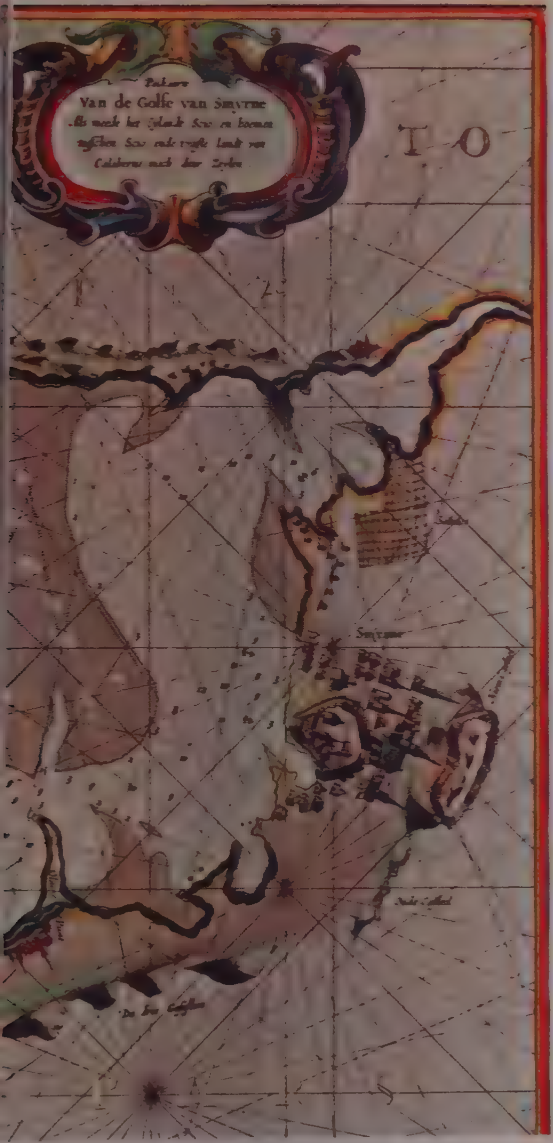


(Figs. 3, 4) Details from a manuscript sea-atlas drawn in 1558 by the Portuguese hydrographer Diogo Homem, probably for King Philip II of Spain and Queen Mary of England. Charts of this kind, drawn on vellum which took the colours with special brilliance, were lavishly illuminated for presentation to important patrons. The scientific precision with which the coast-lines are delineated is in curious contrast to the mediaeval fancy shown in adorning the "voide places" of the interior

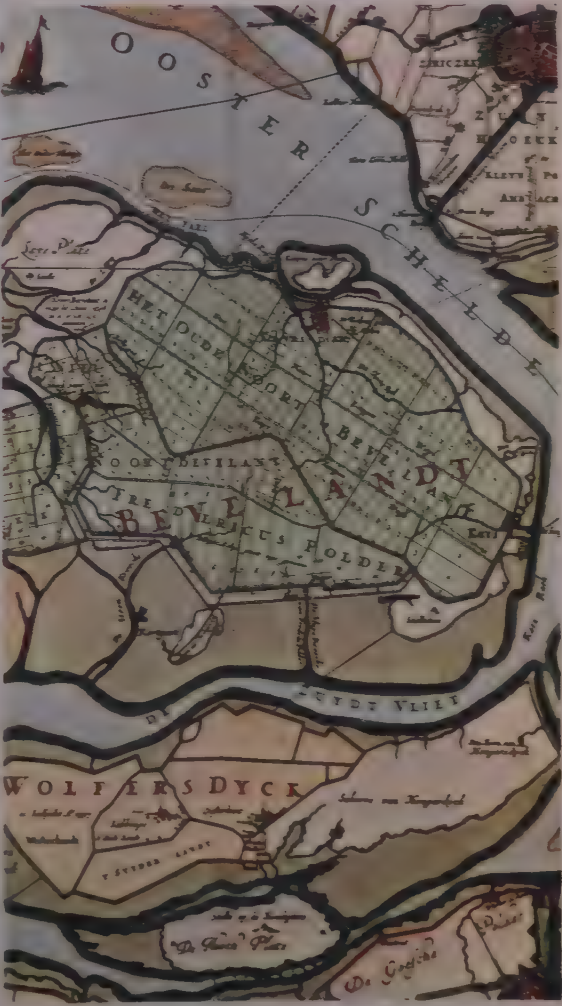




(Fig. 5: *above*) Detail from Christopher Saxton's map of Wiltshire, engraved in 1576, with the restrained colouring of the later 16th century. The topographical tints are conventionally realistic: water blue; tree-symbols blue-green; the sugar-loaf mountains shaded in green and brown; symbols for towns and villages red. The county boundaries are outlined with colour. (Fig. 6: *left*) "Description of the Towne of Mannados or New Amsterdam . . . September 1661." This anonymous manuscript plan of New York, probably made after the English occupation in 1664, displays the greater flamboyancy and denser colouring, often in oils, characteristic of its period. The compass-rose and border are done in vivid poster hues, and the artist has grasped the opportunity for colour offered by the flags and lettering. Water is blue, and grass green; and the houses, drawn in elevation after the contemporary fashion, have buff walls and red roofs

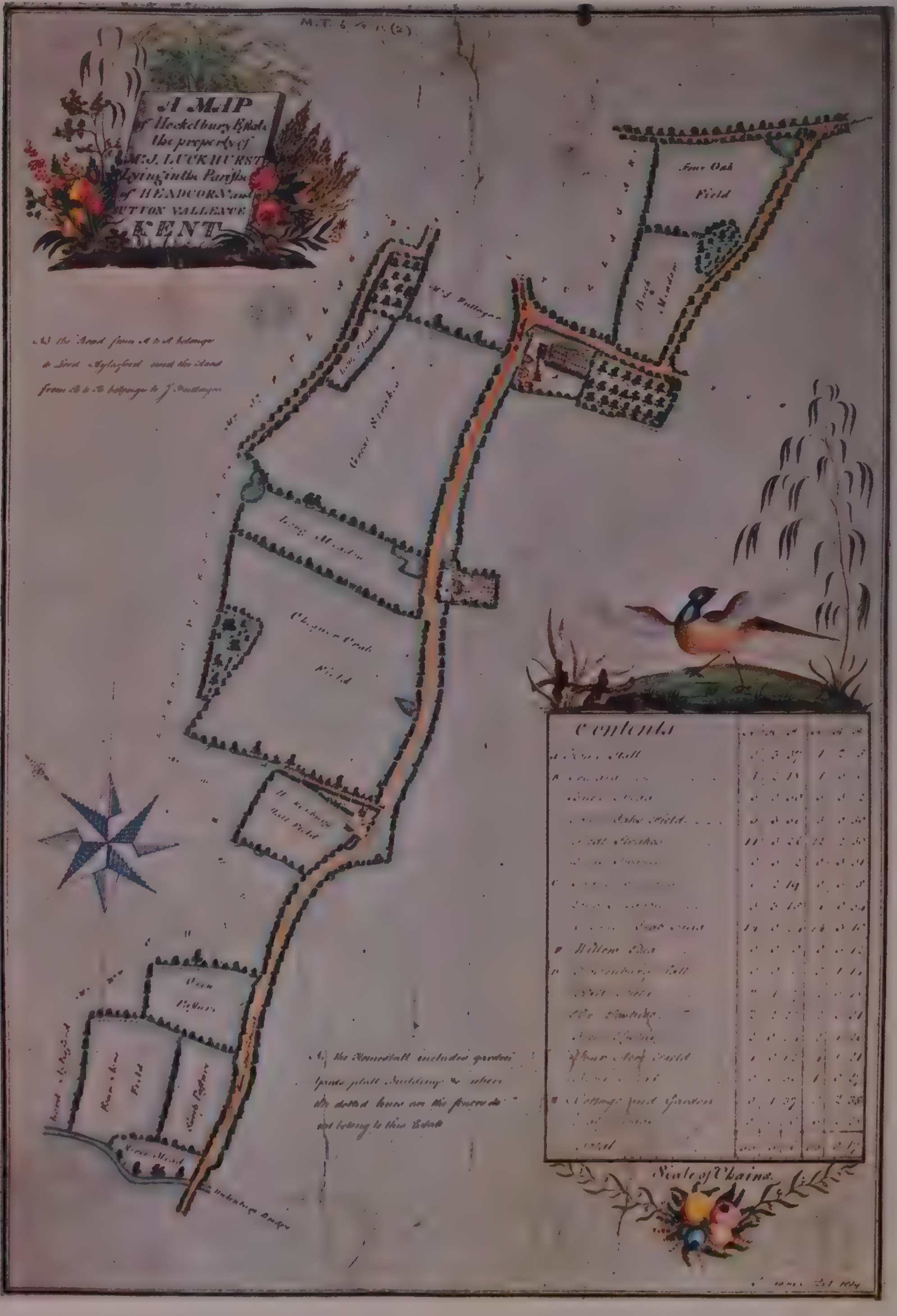


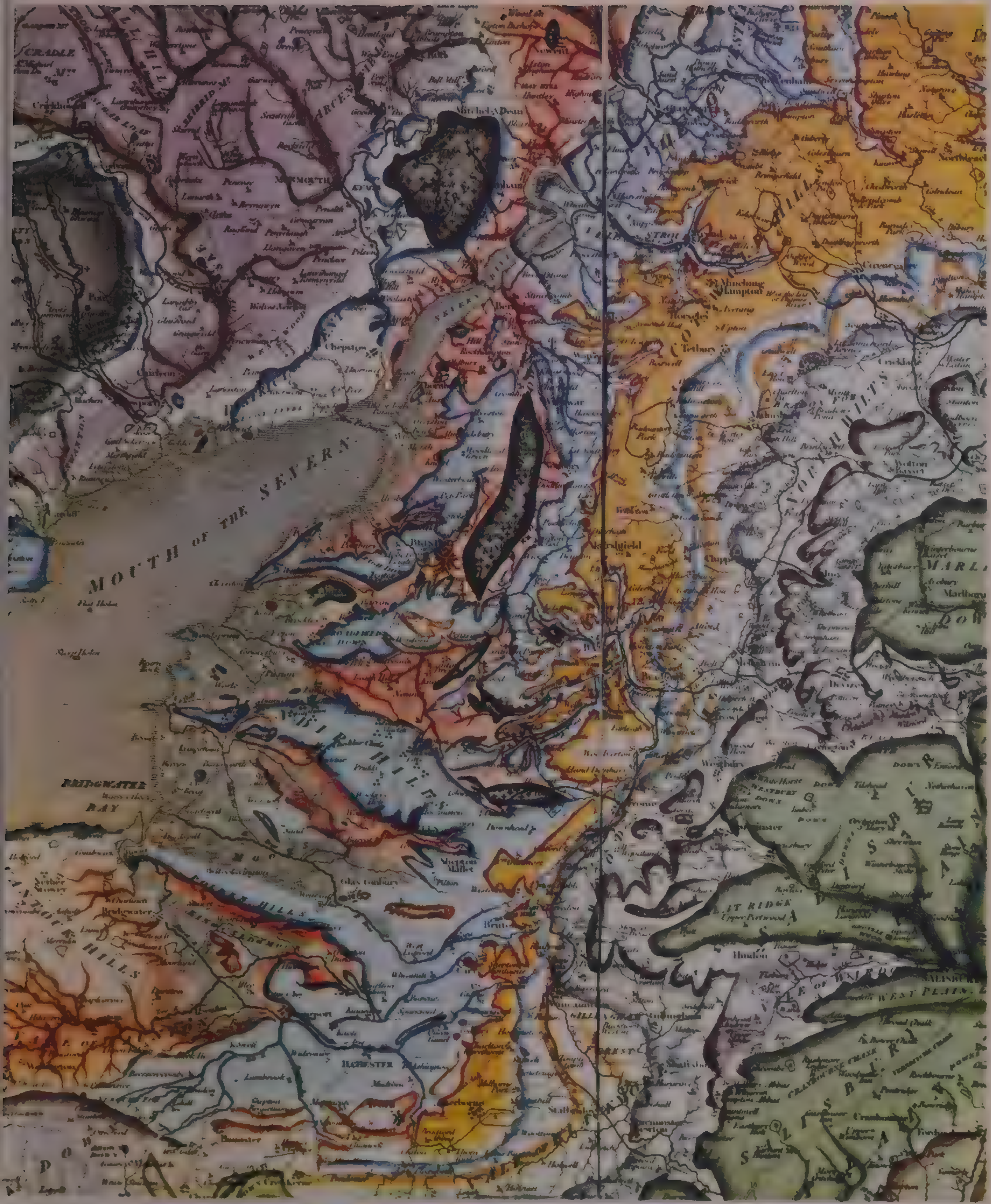
(Fig. 7: *left*) Detail from an engraved chart of the Gulf of Smyrna, in the sea-atlas by Pieter Goos, *De Zee-Spiegel*, part III, published at Amsterdam in 1662. This finely illuminated copy, with much use of gold-leaf, was prepared for the library of a rich collector rather than for practical use by the seaman. The colourwork illustrates the skill of the Dutch in combining naturalism (as in the pale brown wash used for sands and shoals) with decorative quality. The coastline is emphasized by narrow bands of blue, brown and yellow; and the artist has allowed himself much licence in colouring—in reds, greens, blues and browns—the coastal landmarks which (according to chart-makers' practice) are drawn in elevation as viewed from the sea



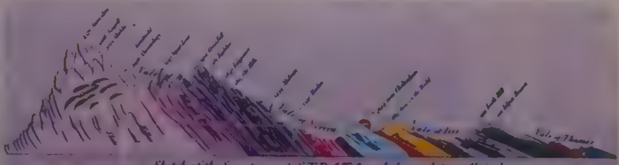
(Fig. 8: *right*) Detail from a map of the islands of North Beveland and Wolfersdyk, Zeeland, in the mouth of the River Scheldt, engraved at Amsterdam in the early 18th century. Here, as commonly in Dutch maps, land use and the relationship of land and water are clearly expressed by colour. Water is blue, with black hatching inshore; sands and dunes yellow-green; enclosed and cultivated land is pale green; unenclosed land yellow or buff. All these colours are transparent washes. Settlements are done in a denser red; towns drawn in plan; villages indicated by a church-symbol. Administrative limits are outlined in bright colours

(Fig. 9) This manuscript plan, drawn by John Adams in 1809, illustrates the exuberance with which estate surveyors embellished their work. The plan's colouring is realistic, with hedges green, water blue, roofs red and roads brown, while the motifs of the external ornament are in their proper hues

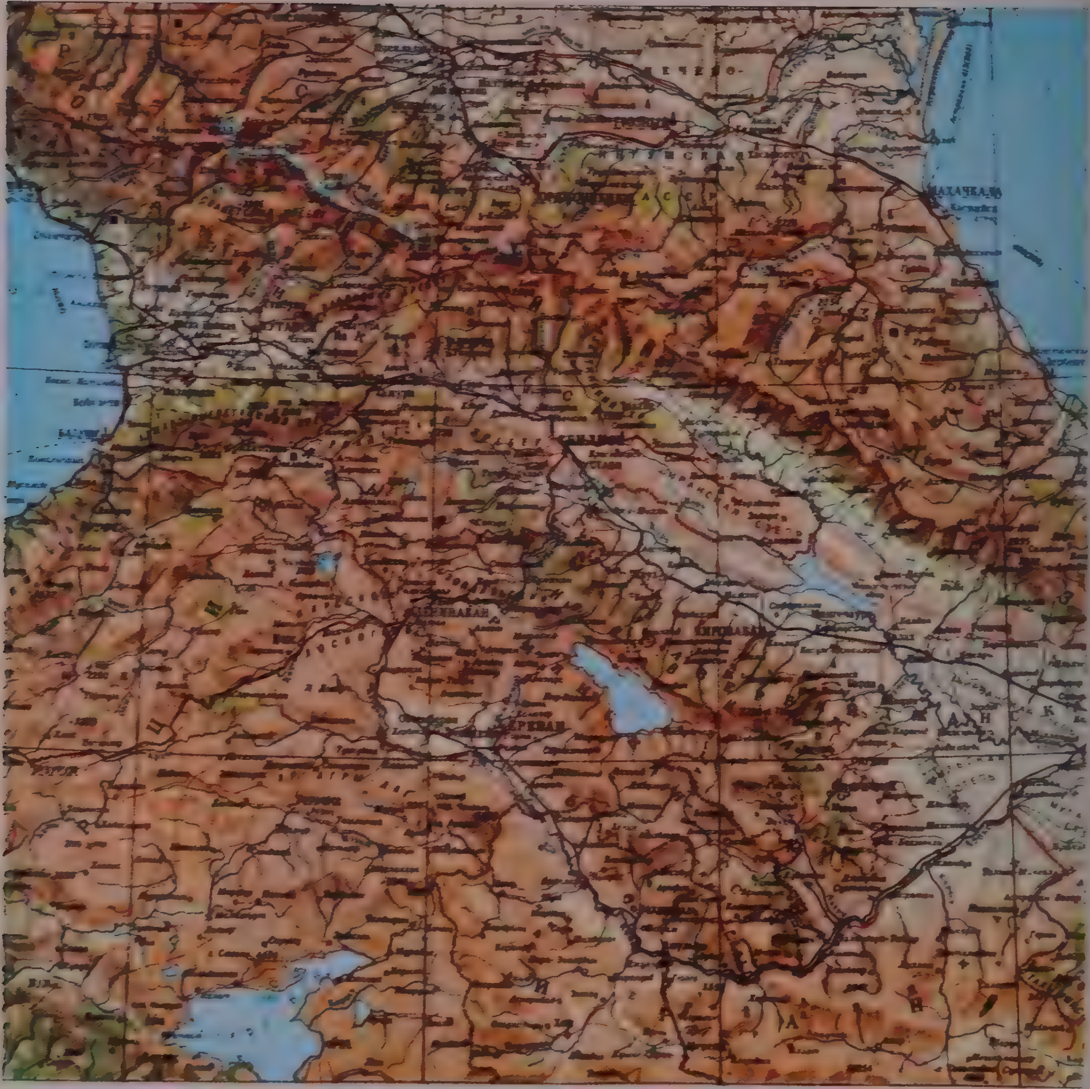

M.T. 6
A MAP
of Heckelbury Estate
the property of
M.r J. LUCKHURST
Lying in the Parish
of HEADCORN and
SUTTON VALLENCE
KENT
N.B. the Road from A to A belongs
to Lord Aylesford and the Road
from B to B belongs to J. Pattenden
Four Oak
Field
Long Meadow
Great Stocks
N.B. the Homestall includes garden
yards plats Buildings &c. where
the dotted lines are the fences do
not belong to this Estate
Contents
Willow Plat
Cottage and Garden
Scale of Chains



Figs. 10, 11) Use of colour in a geological nap: from William Smith's *Delineation of he Strata of England and Wales* (1815). *Right)* Smith's stratigraphic section. His geological colouring was "assimilated to the colour of each stratum, except chalk, which, being colourless, seemed best represented by green", while black indicated coal measures



Sketch of the Succession of STRATA and their relative Altitudes



From the Atlas Mira, by courtesy of the publishers

(Fig. 12) Map of the Caucasus, from the Russian *Atlas Mira* (1958). Colour is employed to direct the eye to the shape and trend of the relief, without any attempt (as by contouring) to show absolute altitude. Increasing height is rendered by tones of brown, from light to dark, and the perspective effect is strengthened by deeper shading as if thrown by oblique rays from the north-west. The traditional colours are borrowed from nature for water and woodland, and roads are in red. Sand features are represented by a brown stipple, and areas of perpetual snow by a blue stipple, on a white background decoration of borders and cartouches, but economically on the face of the map. The ingenuity of cartographers was engaged in the elaboration of linear topographical symbols, to which colour could add little significance. But the end of the 18th century and beginning of the 19th mark the rise of applied cartography, in which the data of various sciences are plotted in their geographical distribution or extension. Mapwork of this kind required (as it were) an extra dimension, which could be communicated only by tones or colours. The enlargement of the content of maps created new and varied tasks for colour. In the earliest geological maps the pattern of rocks was distinguished by different types of shading and stipple; but from 1794 the soil maps of the Board of Agriculture employed colours to indicate the texture and fertility of soils. The tables of strata based on their associated fossils, drawn up by the "mineral surveyor" William Smith, served as the key to the geological colouring of his maps (Figs. 10, 11).

But it was in the field of human or social geography that colour found its widest applications. In a map of the London region published in 1800, Thomas Milne employed colours and letters to differentiate seventeen forms of land use, foreshadowing the land-utilization surveys of today. Cartographers of the first half of the 19th century used monochrome aquatint shading to represent population density and other distribution factors; but in August Petermann's map of the British Isles, published in 1849, variously coloured symbols denoted the density of population of the cities. From such beginnings has sprung the great family of special or thematic maps, in which the phenomena of physical nature and many aspects of human life and work are now depicted by coloured overprints on a topographical base. A distinguished series of such maps, "depicting the primary physical, economic, human, and social facts concerning the country as a whole", has been produced by the Ordnance Survey at a scale of 1:625,000 (about 10 miles to an inch) and constitutes the nucleus of a National Atlas of Great Britain.

The introduction of colour-lithography in the middle of the 19th century brought about a technical revolution which profoundly influenced map-production. It placed at the printer's disposal a mechanical process for reproducing flat, and even transparent, colours; it eliminated the immense manual labour of applying colours separately to each copy and of checking the correctness of every copy; and it ensured uniformity throughout the printing of a map. Hand-colouring (whether by freehand or stencils), indeed, died hard: it continued to be used in the 25-inch plans of the Ordnance Survey until 1909, and the first colour-printed map of the Geological Survey appeared only in 1902. But hand-colouring could not long survive the competition of lithography and zincography, nor vie with the greater range of expression which colour-printing gave to the cartographer.

The benefits of colour-lithography were not confined to special maps. In topographical mapping it transformed the representation of relief, increasing its flexibility and power of visual suggestion. In this part of his task the mapmaker could be served by colour in various ways, principally as hypsometric or layer tints, applied to the spaces between adjacent contour lines, or in the form of hill-shading. Layer-colouring was added (by hand) to the maps of Stieler's *Hand-Atlas* from 1820, and by the middle of the century it had established itself (under the influence of Berghaus) in the work of German cartographers, using chromolithography. In 1888 J. G. Bartholomew began the publication of his layer-coloured half-inch maps, to be followed by the Ordnance Survey map on the same scale begun in 1902. Colouring of this type usually ranges from shades of green (at the lower levels) through yellows and browns to red and purple, with the highest levels uncoloured, and produces a clear image of the relief system, although it may be said to disguise the slope, or shape, of the surface. For this latter purpose hachures (lines drawn in the direction of the slope) and hill-shadows are more expressive. Coloured hill-shading, in brown, was in 1898 first added to the Ordnance Survey one-inch map (third edition), the relief version of which was printed in six colours. Today the Ordnance Survey uses layer tints and hill-shading in its quarter-inch map, layer tints in the half-inch map, and contours alone in the standard one-inch map. In its one-inch tourist maps, however, purple and grey-blue slope shading (from an oblique north-west light) creates a stereoscopic effect of "aerial perspective". Modern maps on smaller or atlas scales, such as those of the *Oxford Atlas* or the Russian *Atlas Mira* (Fig. 12), use layering or hill-shading in colour, often without contours, to enable relief forms to be clearly visualized.

Atlases Today

by PROFESSOR W. G. V. BALCHIN

of the Department of Geography, University College of Swansea

To some of us it is quite astonishing to see how many kinds and sizes of atlases can now be bought or consulted. At school we often saw only a thin, flimsy volume, in which political maps, exciting with their splashes of bright primary colours and their clearly defined frontiers, alternated with the layered greens and browns of the physical maps. Today the map which claims our interest is the one which shows the world distribution of ground-nuts or bauxite, precipitation in July, or the polar ice-caps over which aircraft cut short the earth's great distances. Moreover, all kinds of new distribution patterns have in recent years been mapped, with the result that there are now several hundred modern atlases of a wide variety available. Most if not all, however, fall into one of four categories: the atlas may either deal with the **world** as a whole or be confined to a **region** of the world; and within each of these two main subdivisions the treatment may be either **general**, covering a wide variety of topics, or **special**, covering restricted topics. The characteristics of each of these groups, a necessarily limited selection of examples, and an indication of the main cartographic innovations of recent years are considered in the following pages.

General World Atlases are designed to meet widely diverse needs, for they are found in libraries, schoolrooms, offices and the home. Their main use is for locating places in the news, planning journeys, estimating distances and checking on markets and trading areas. They range in size from the large library atlas (once referred to as a "Hand" atlas but weighing many pounds) to the small pocket atlas for school use. The maps are largely topographical and political but other information may also be covered.

Pre-eminent in the field of large library atlases is the Mid-Century Edition of *The Times Atlas of the World*, of which the fifth and last volume has now been published. *The Times Atlas* provides general reference maps covering the whole world on relatively large scales for an atlas, and it bridges in a convenient fashion the gap between the smaller-scale maps of the normal atlas and the large-scale single-sheet topographic map. There are few parts of the world that are not covered in the atlas on a scale larger than 1:5,000,000, and much is available on scales as large as 1:1,000,000 (nearly 16 miles to an inch). Compiled by the House of Bartholomew (which has just been celebrating the centenary of the birth of its founder, John Bartholomew) and printed by deep-etch photo-offset, the result is of a high cartographic standard with first-class colour effects, sharp outlines and excellent registration.

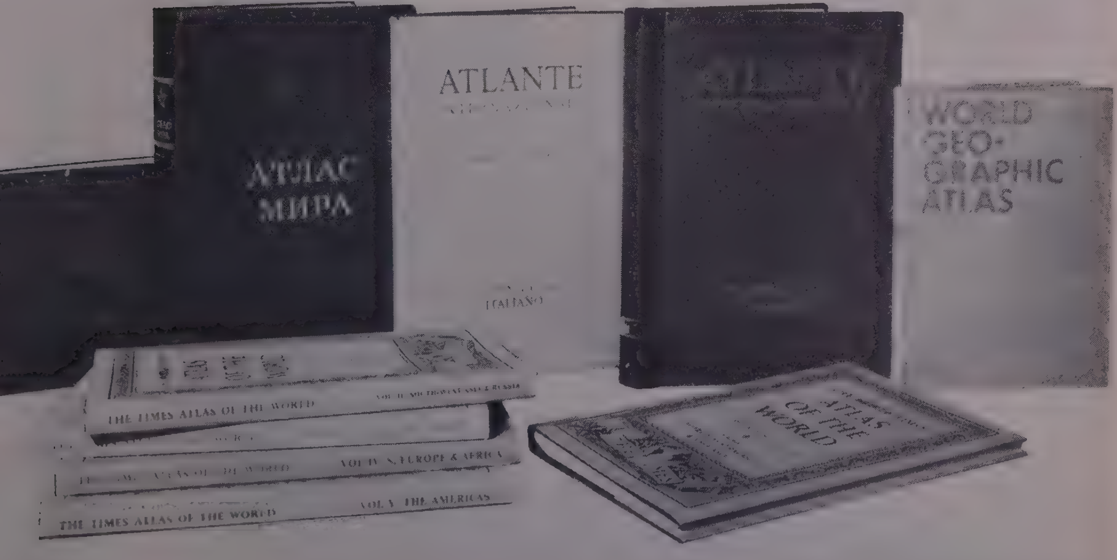
In the same class of a 'Grand Atlas' is the *Atlas of The Touring Club Italiano* and the Soviet *Atlas Mira*. The first of these, the *Atlante internazionale della Consociazione Turistica Italiana*, to give its full name, was reissued in 1955–56 to mark the sixtieth anniversary of the Club's foundation. With 173 plates and an index of some 200,000 entries, it is, like *The Times Atlas*, a comprehensive work of reference.

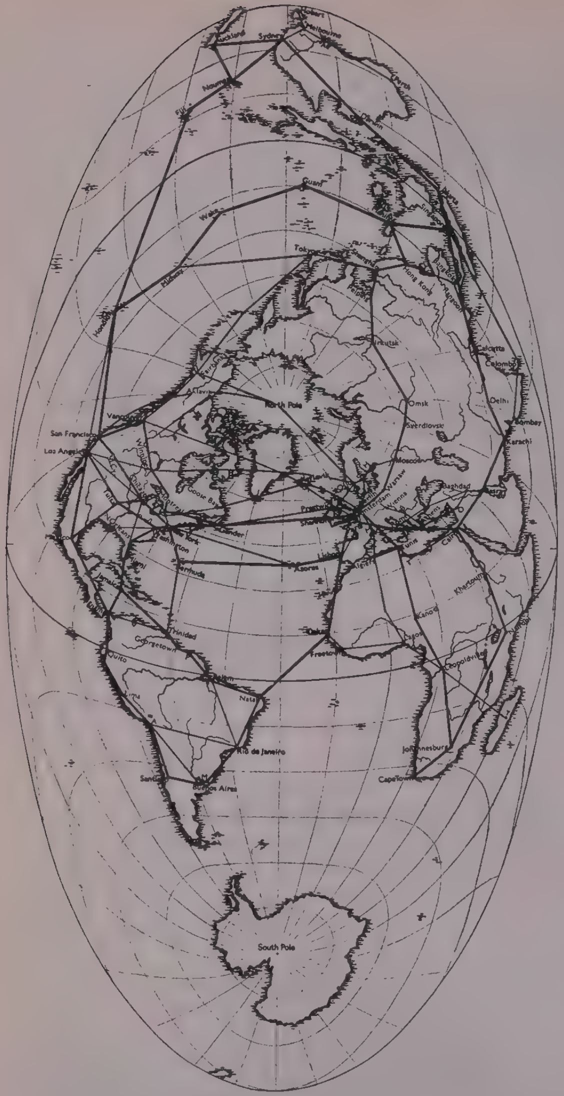
The Soviet *Atlas Mira*, published in 1954 by the Chief Directorate of Geodesy and Cartography (G.U.G.K.), replaces the 1939 *Great Soviet World Atlas*. The atlas includes general world maps followed by continental groups, with the emphasis on topographical, political and transportation maps. The coverage is well distributed over the continental groups but there is naturally some concentration on the Soviet Union. With 261 separate maps covering some 344 square feet and an index of over 200,000 names the *Atlas Mira* certainly ranks as one of the Grand Atlases. The rendering of foreign place names in Cyrillic script, however, limits its use.

The only American production comparable with these three giants of the atlas world is Bayer's *World Geo-Graphic Atlas* of 1953 which has 273 pages of colour-plates. This was privately printed for the Container Corporation of America and only a limited number of copies are available. It differs from the foregoing atlases in that it includes many plates from other atlases. Perhaps its most original contribution is the descriptive text accompanying most of the maps.

Other large but older general world atlases

(*Above*) Atlases used by students. The *Advanced Atlas*, *Oxford Atlas* and *University Atlas* are British. The *Faber Atlas* is Austrian, the *Larousse* is French, and *Goldmanns* is German. (*Below*) Grand Atlases. *The Times Atlas of the World* from Britain, Italy's *Touring Club Atlas*, the Soviet *Atlas Mira*, and Bayer's *World Geo-Graphic Atlas* from the United States





From Bartholomew's Advanced Atlas of Modern Geography *(5th edition, 1960), by courtesy of Oliver & Boyd Ltd*

The Atlantis projection, in which areas are shown in their true relation, but with some distortion of shape: devised by Bartholomew, it shows major world airways

include Stieler's *Hand-Atlas* and the *Grand Atlas de géographie moderne*, both of which appear to have become wartime casualties; and there is also the *Encyclopaedia Britannica World Atlas* (Chicago) and the *Rand McNally Commercial Atlas* (New York).

General world atlases in our next group are smaller in size and include many that will be familiar to the average person, as they are in wide use in libraries, schools and in the home. Some, such as Bartholomew's *Oxford Advanced Atlas* and *Citizen's Atlas of the World*; Philips' *University Atlas*, *International Atlas* and *Mercantile Marine Atlas*; and Goode's *School Atlas* are old friends that have run to many editions during the last few decades.

A number of quite new general world atlases have, however, appeared in the post-war years, and of these the *Atlas International Larousse Politique et Économique*, published in Paris in 1950, is one of the most outstanding. Although intended for general reference there is also an emphasis on economic maps and statistics; the maps are no longer organized by continents but rather on significant spatial relationships, whilst polar projections are used for the "air-age geography". The international character of the atlas is further emphasized by the multi-language legends in English, French and Spanish, and the use of local place-name renderings. The established concept that a general world atlas should be merely physical and political in character is widened in this atlas very substantially to show sources of energy, mines, agriculture, heavy industry, air lines, population, etc., with a commentary to each map in the three languages.

A second completely new and notable post-war production is the *Oxford Atlas*, first published by the Oxford University Press in 1951. The general section of the first edition appeared with eighty-eight page plates in colour followed by twenty-four colour-plates dealing with important natural and human distributions. These include maps of seasonal precipitation and temperature, population, vegetation, structure and land use for both world and selected regional areas. Colour is used very effectively in this atlas and a number of projection innovations have been introduced. Oblique and transverse cases of the Mercator and other orthomorphic projections have been used where appropriate, together with several completely new projections, which diminish distortion and give new aspects of global relationships.

Bartholomew's *Advanced Atlas of Modern Geography* (1950) is another post-war publication with some interesting innovations. A definite attempt has been made in this atlas to fit the projection to the purpose of the map and several new portrayals of world distributions result. Some are based on the "Nordic" projection, which gives an excellent equal-area arrangement of the populated land masses completely free from distortion and with the Arctic Sea uninterrupted. Another projection—the "Atlantis"—shows world airways to advantage. Recentred

Sinusoidals and 'butterfly' regional projections are also used effectively. The index represents a further departure from tradition with a world-wide geographical co-ordinate system related to a world grid based on Greenwich.

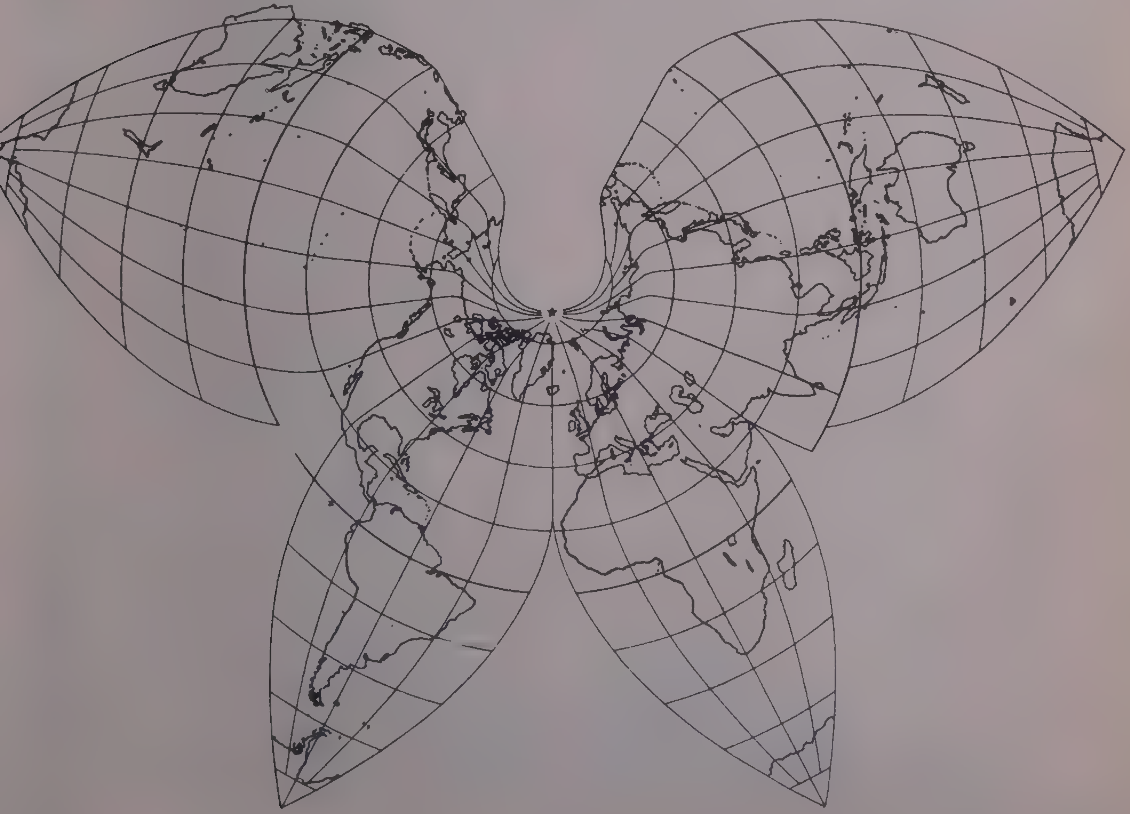
Philips' *Reference Atlas* is also claimed as an entirely new post-war production. With 120 plates it is more conventional in its appearance and seems to be mainly intended for locating places, although some general introductory maps are included. Political and administrative aspects dominate this atlas and the principal maps do not indicate relief visually.

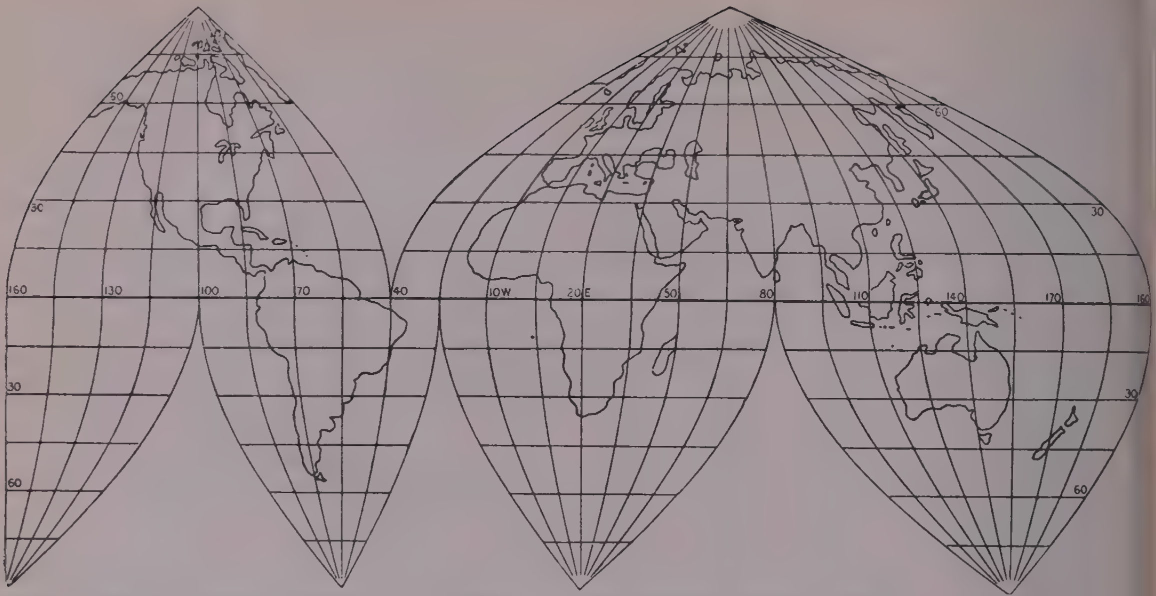
Amongst other new and post-war productions mention should be made of Rand McNally's *Cosmopolitan World Atlas* (1956) which is one of the best atlases yet published in the United States; the *Atlas du XX^e siècle* (Paris, 1948) which is a French production partly based on the *Atlas de France*; *Goldmanns Grosser Weltatlas* (Munich, 1955) which has so many supplementary features that it is almost a graphic geographical encyclopaedia; and the *Atlas Universal Aguilar* (Madrid, 1954) which is a Spanish attempt to portray the world, and also includes a text on general and regional geography and a large number of illustrations. From Italy comes the *Atlante Geografico Zanichelli ad Uso delle Scuole* (Bologna, 1947) which is notable for its treatment of urban geography; and from Switzerland the *Schweizerischer Mittelschulatlas* (Zürich, 1947) which exhibits the usual high standard associated with Swiss cartography; whilst the *Faber Atlas* (1956) is an interesting production by Ed. Hölzel of Vienna intended for the English-speaking market and especially for teaching.

Special World Atlases feature aspects of topical distribution. Economic resources, commercial activities, climate, agriculture and historical geography spring to mind as the most frequent subjects dealt with. Such atlases are invaluable for obtaining comprehensive pictures of the distribution of specific commodities and

Bartholomew's Regional projection of the World. Designed to combine accuracy of shape as far as possible with accuracy of scale, this is of the type also known as a butterfly projection

From Bartholomew's Advanced Atlas of Modern Geography *(5th edition, 1960), by courtesy of Oliver & Boyd Ltd*





From J. A Steers's An Introduction to the Study of Map Projections, *by courtesy of University of London Press Ltd*

The 'interrupted' Sanson-Flamsteed equal-area projection, in which each land mass is separately drawn on a selected meridian, shows the shapes and sizes of the continents to the best advantage

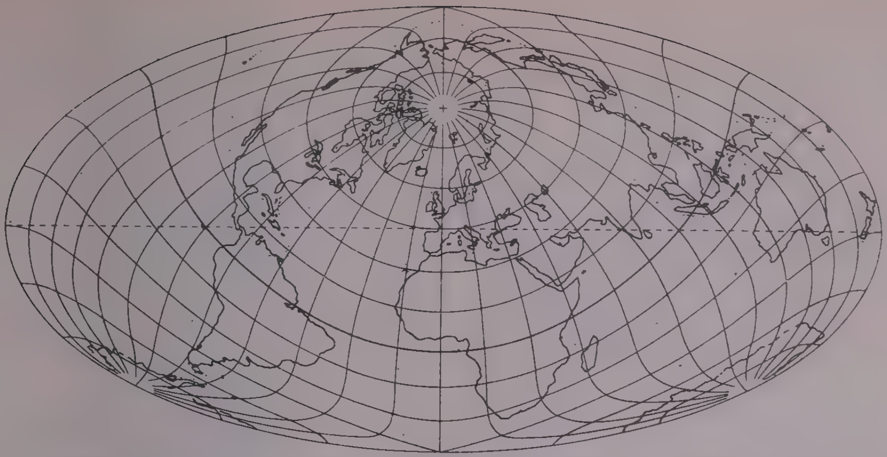
for comparative studies.

Amongst modern Special World Atlases particular mention should be made of the *World Atlas of Diseases* which is now being produced by the American Geographical Society. This is an extension to the whole world of the idea behind the *Seuchen-Atlas*, a wartime German production showing epidemic diseases in the areas for which military operations were planned. A considerable number of the American world maps have now been issued showing the distribution of various diseases.

In the field of economic geography notable post-war productions include *The Mineral Resources of the World* (1952) by William Van Royen and Oliver Bowles, and *The Agricultural Resources of the World* (1954) by William Van Royen. Both of these atlases were produced by the University of Maryland, are large and expensive, and clearly can only be regarded as library volumes. The general student has a choice between two alternative and very interesting atlases. The *Oxford Economic Atlas of the World* (1954) attempts a specific coverage of world commodities and has an accompanying commentary. Physical factors affecting crop production, standard continental reference maps, the distribution of agricultural commodities, minerals and basic manufactures, together with data on population, air and surface communications and monetary conditions are all covered in this commendable world economic atlas. The other is Johannes Humlum's *Atlas of Economic Geography* (1955). This is a Danish work which attempts a cartographic summary of post-war production and trade for the student at the international level, all the prefatory remarks and map explanations being in Danish, French, German and English. The representation of economic statistics by cartographic means is of considerable value in that the maps remain useful much longer.

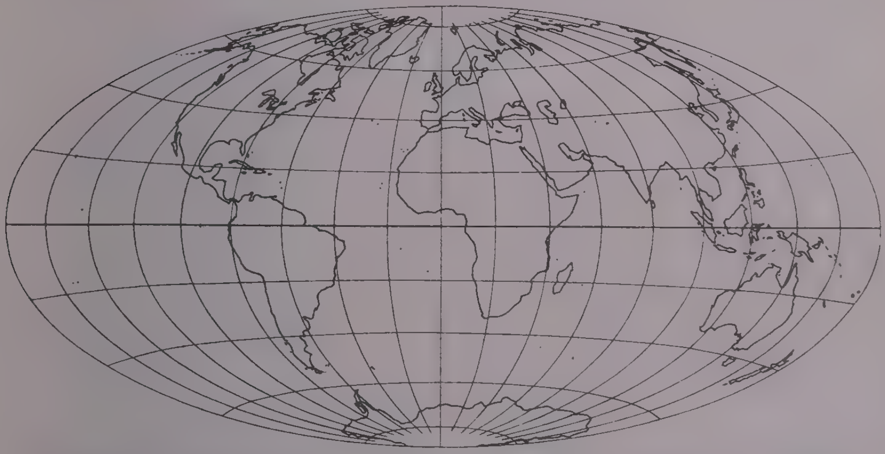
A final and somewhat unusual illustration in this category of special atlases is the *Relief Form Atlas* edited by A. Cholley and published in 1956 by the French Institut Géographique National. It is based upon a selection of air-photographs presented with contour maps of the same areas.

General Regional Atlases concentrate upon a specific region and attempt the portrayal in greater detail of the type of information found in the general world atlases. These atlases are the specialized tools of the scholar, serious researcher and planning authorities. They are most often published by official government agencies and appear in the form of "National Atlases". There are now well over twenty substantial volumes that fall into this category and most of the more important political units of the



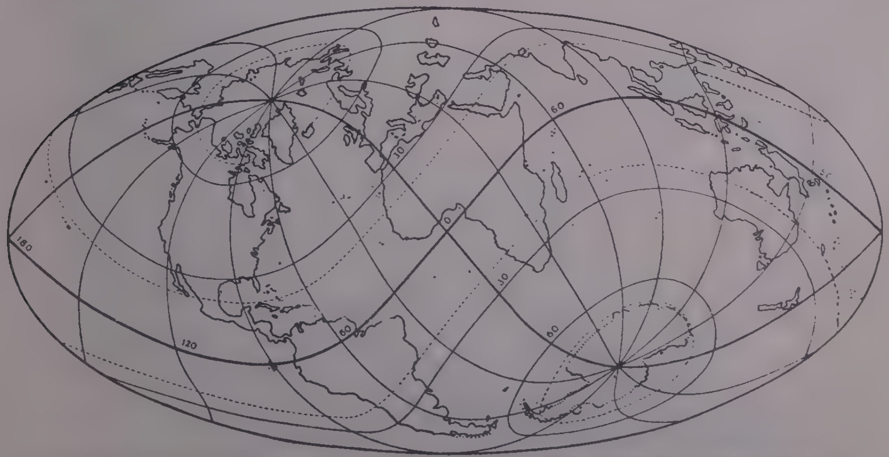
From Bartholomew's Advanced Atlas of Modern Geography *(5th edition, 1960), by courtesy of Oliver & Boyd Ltd*

(*Above*) The Nordic equal-area projection for distribution maps in northern latitudes



From Bartholomew's Advanced Atlas of Modern Geography *(5th edition, 1960), by courtesy of Oliver & Boyd Ltd*

(*Above*) An equal-area projection, Aitoff's, of the World; and the Oblique Mollweide (*below*), also equal-area, which shows the relative areas of the British Commonwealth



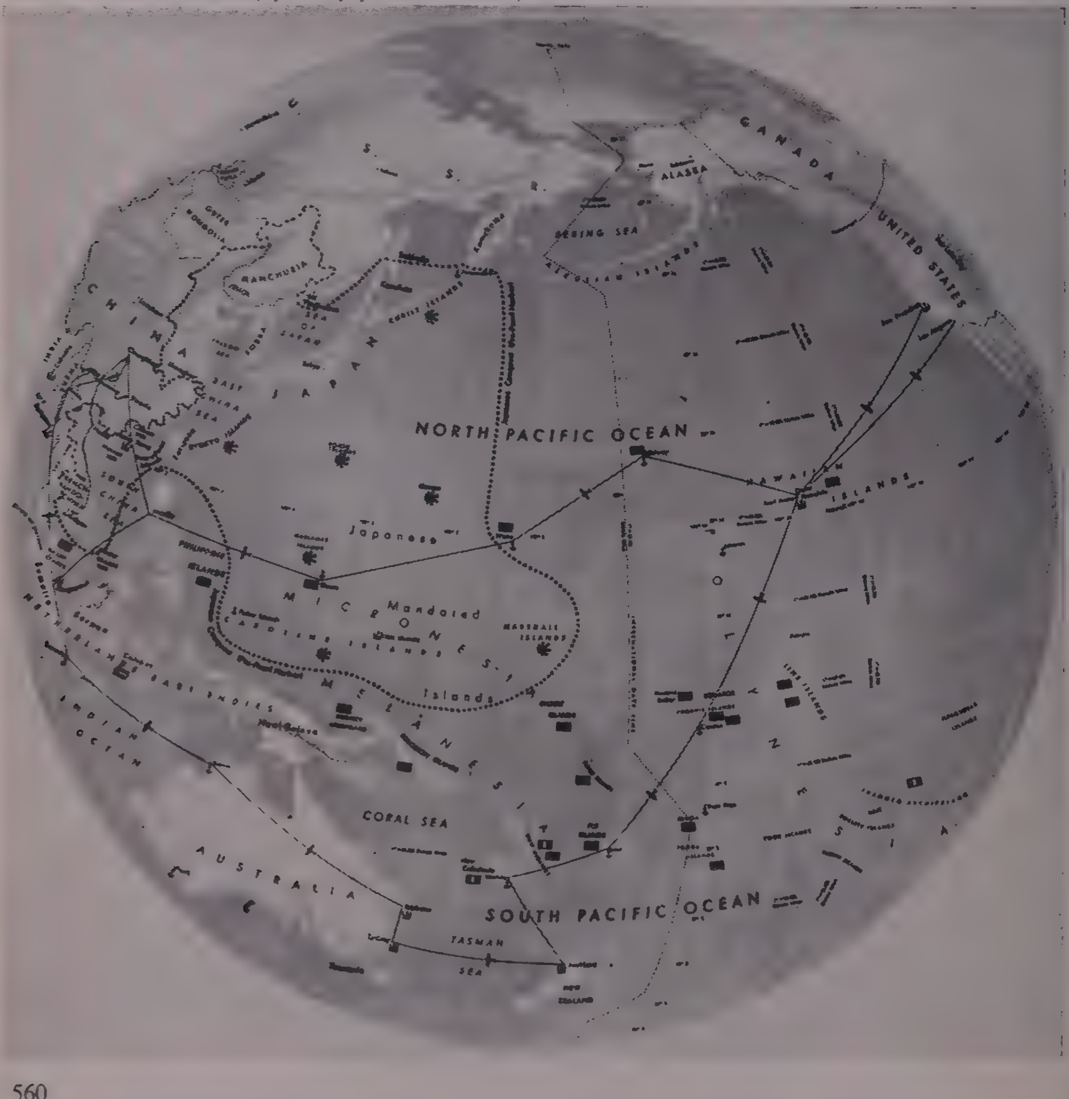
From J. A. Steers's An Introduction to the Study of Map Projections, *by courtesy of University of London Press Ltd* world are now so covered.

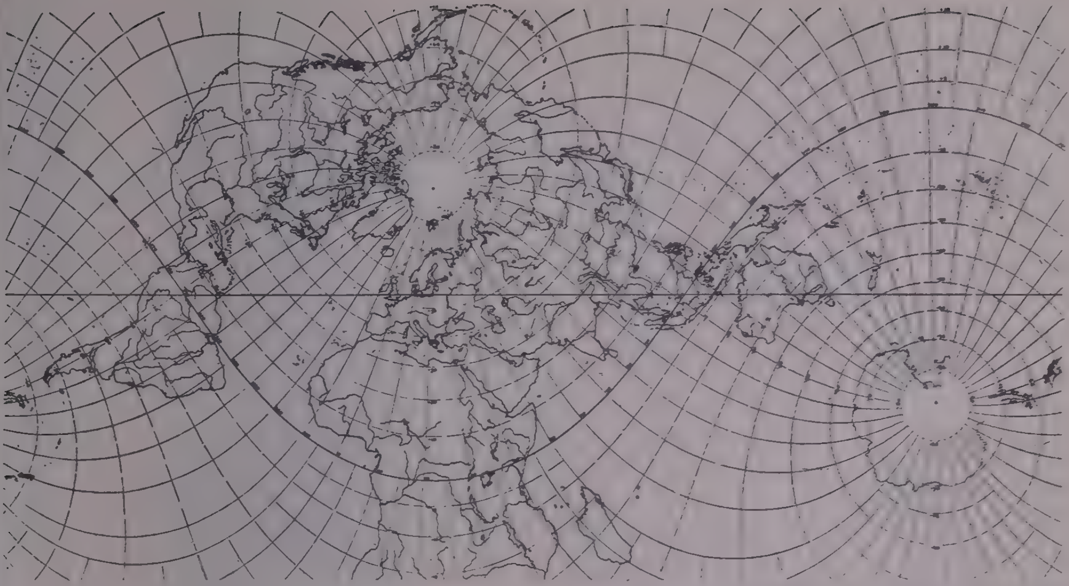
As might be expected, Europe has led the way in the production of national atlases and these now exist for Austria, Belgium, Czechoslovakia, Denmark, Finland, France, Federal Germany, Italy, Norway, Poland, Portugal, Sweden and the Soviet Union; but not, it will be noted, for Great Britain, although much useful material has been issued here in separate sheets in the 1:625,000 (nearly ten miles to an inch) series. In North America both Canada and the United States are undertaking national atlases and a considerable number of sheets have been published, whilst the recently issued and magnificent *Atlas of Resources for British Columbia* (Vancouver, 1956) should also be mentioned as an excellent example of a general regional atlas. In Central and South America there are as yet no true national atlases, but a number of statistical productions have appeared that will clearly lay the foundations for future publications, notably for Brazil, Costa Rica, Salvador and the Dominican Republic.

Asia is by comparison deficient in national atlases, though India has within the last year

Projections which give the viewer the impression that he is looking at a globe are known as "orthographic". This is an oblique version, in which the point of projection is 20° N, 170° E

From A War Atlas for Americans, *by courtesy of Simon and Schuster, Inc*





By courtesy of the Royal Geographical Society

This oblique Mercator projection was designed by A. R. Hinks, a former Director of the Royal Geographical Society, to include the polar regions, which cannot be shown on a normal Mercator

produced an important national atlas, and Israel has one in production. In Africa, on the other hand, the Belgian Congo, Ghana (as the Gold Coast), Egypt, Tanganyika, Algeria and Tunisia, and Morocco have all issued national atlases within the last two or three decades. Australia is now being covered by the *Atlas of Australian Resources*, and plans have been advanced for a *National Atlas of New Zealand*.

All of these atlases portray a wide variety of information ranging over the relief, geology, climatology and hydrology of the chosen region, together with the historical background and social and economic conditions of the area. The aim in every case is to show all the relevant aspects of the country and this is often achieved by many ingenious cartographic methods. Those atlases in the less familiar languages are now frequently provided with legends, keys, titles and text summaries in either French or English.

In addition to the national-type atlases, which are nearly always official publications, there are a number of general regional atlases produced by commercial publishers. Bartholomew's *Survey Atlas of England and Wales*, the *Atlas colonial français* and the *Provincial Atlas of the Chinese People's Republic* are typical examples.

Special Regional Atlases constitute the fourth and final category of our analysis. Here the special topic may feature such varied subjects as geology, climatology, meteorology, historical geography, economic and social geography, land utilization, soils, military and political conditions, etc., whilst the region may range from a city to a continent. With such potentialities it will be clear that the possible number of special regional atlases is almost limitless—and a very large number do in fact already exist in this category. In this brief review I can only touch upon a selection of the modern publications.

Climatology and meteorology have naturally given rise to some fine regional atlases, more especially for Great Britain (H.M.S.O.), Canada (National Research Council, Ottawa, 1953), the United States (Harvard University Press, Cambridge, 1954), Japan (Central Meteorological Observatory, Tokyo, 1948–49), East Asia (Tousewei Press, Shanghai, 1944) and Israel (Hebrew University, Jerusalem, 1950).

The field of economic geography is also well represented by a number of agricultural atlases covering the British Isles and North America. The *Atlas of American Agriculture* published by the U.S. Department of Agriculture has long been regarded as a classic in this group. Industrial geography is represented by the French *Atlas de l'industrie textile* (Paris, 1948) and the

In the Royal Geographical Society's Map Room and Library are nearly half a million maps, some hundred-thousand books and several thousand atlases, one of the largest geographical collections in existence

Atlas hydroélectrique de France (Paris, 1945). General economic conditions in a region may also be treated as in the Oxford series of *Regional Economic Atlases*; that covering the U.S.S.R. and Eastern Europe is a notable example.

In the same way historical geography has given rise to many regional atlases, amongst which special mention should be made of the *Atlas of Western Civilization* (Elsevier Publ. Co., Amsterdam, 1954) which is supported by a text and over a thousand photogravures. Historical atlases have also been published for the United States (by the American Geographical Society) and more recently for Switzerland (*Historischer Atlas der Schweiz*,1951), Israel (*Atlas Geographi-Histori Shel Eretz Yisrael*, 1955) and Soviet Russia (*Atlas istorii SSSR*, 1954–55).

Other recent special regional atlases range from the *Ice Atlas of the Northern Hemisphere* (Hydrographic Office U.S.N., 1946) to the *Atlas der Schweizerischen Volkskunde* (Atlas of Swiss Folklore, Basel, 1950–51) and the *Atlas de la France vinicole* (Paris, 1949), produced as a "cartographic poem to glorify French wines". In contrast we have *Les tourbières françaises* (Paris, 1949) which deals with the distribution of peat bogs, and the *Linguistic Atlas of New England* (Brown University, 1943) which maps speech-forms. It would seem that there is little that the cartographer has not attempted.

Recent Innovations. Although by now there is much standardization in atlas-making, this does not mean that innovations no longer occur. In fact there have been many since the war.

Foreign atlases increasingly feature their map titles, legends and keys in English or French to widen their appeal. The old-style atlas which consisted of maps alone seems to be giving way to atlases supported by textual matter, graphs, cartograms, block diagrams, photographs and statistical tables. Economic atlases are supported by statistical tables, cartograms and graphs, as in the *Oxford Economic Atlas of the World* (1954) and Humlum's *Atlas of Economic Geography* (1955).

Another innovation is a tendency to organize completely new atlases by major regions rather than by individual countries—the *Atlas International Larousse* (1950) is a good example. This, along with the necessity to recognize the arrival of the "air-age geography", has had an effect upon the projections which may be chosen or devised. The air age has increased considerably the number of polar projections now found in modern atlases, and the regional approach has encouraged the use of interrupted projections, in which a central meridian is newly established for each land mass and distortion is thus reduced. In some atlases there seems to have been a swing away from conventional equal-area projections, in which land and sea areas are given their true relative sizes but subject to distortion of shape, towards orthomorphic versions, in which shapes and directions remain theoretically correct but masses are not consistent with each other in scale.

Experiments also continue with that other cartographic *bête noire*—the representation of relief. In the *Relief Form Atlas* (1956) contoured models have in some cases been photographed from two positions, and superimposed printing in red and green produces a stereo-pair which with the aid of suitable spectacles gives a very realistic three-dimensional effect. In general, however, European atlases continue to favour the representation of relief by layer tints, while hachures and physiographic representations seem more popular elsewhere, especially in the United States, although there is a considerable loss of accuracy and legibility.

In the equally thorny realm of orthography, where differences in the spelling of place names can be so irritating, there has been an increasing trend in the post-war period towards the adoption of local renderings for all place names. This policy has been followed in *The Times Atlas* and will doubtless be a feature of all future atlases with an international appeal. Marketing considerations have also encouraged the appearance of multi-language atlases, such as the *Atlas International Larousse* and Humlum's *Atlas of Economic Geography*, which I have already mentioned; and the *Atlas of Denmark*, with legends in Danish and English.

Technical improvements in colour-printing and photogravure processes have permitted further innovations and experimentation. Thus in the *National Atlas of India* as many as thirty-five different tints are used on some maps. The use of half-tone greys has been very effectively demonstrated in the *Atlas of Resources for British Columbia* (1956).

It will be clear that the world of atlas-making has been passing through a very dynamic phase which shows every sign of continuing as a result of changing political conditions, increasing population and a rising standard of living throughout many parts of the world.

The Ordnance Survey

by MAJOR-GENERAL L. F. de VIC CAREY, C.B., C.B.E.

Director General of the Ordnance Survey

THROUGHOUT history war has more often than not played a predominant part in bringing about a National Survey. The need for maps for military purposes having been satisfied, the subsequent maintenance of the survey has been profoundly affected by the threat of war, war itself and the after-effects of war.

In this the Ordnance Survey has been no exception; the National Survey as opposed to the earlier District and County surveys can be said to owe its origin to the defeat of the Young Pretender by the Duke of Cumberland at Culloden on a misty, drizzly day in April 1746.

During the subsequent pacification, if that is the right word, of the Highlands, Cumberland and his staff found themselves severely handicapped by the poor quality of the existing maps of the area. As a result, on the instruction of his Quartermaster General, Lt-General Watson, a systematic one-inch to one-mile survey of the Highlands was commenced.

William Roy, a young engineer aged only twenty at the time of the battle, was an assistant to the Quartermaster General and he played an important part in this survey of the Highlands. In the course of the next eight years most of the Highlands and the Lowlands were surveyed, but the task was never finally completed owing to the outbreak of the Seven Years' War in 1755. Roy, who had now received a commission in the Royal Engineers, was employed for the next few years making plans and reconnaissance maps in Great Britain when he was not serving overseas. In 1765 he was appointed Surveyor General of Coasts and Engineer for making and directing military surveys in Great Britain. Although his duties were mainly of an engineering nature he continued with his survey work whenever opportunity offered. More important, perhaps, from the Ordnance Survey point of view, he continually and vehemently over the next twenty years expressed the need for the establishment of a National Survey. However, it was not until after the end of the American War in 1783 that Roy's recommendations regarding the National Survey were given serious consideration. In 1787, with the active support of George III who presented the great three-foot Ramsden Theodolite to the Royal Society, a triangulation was begun to determine the difference between the meridians at the Greenwich and Paris Observatories. The scientific value of this triangulation, completed in 1788, may be questioned, but there is no doubt that it blazed the trail for the major triangulation of Great Britain which began three years later.

Up to 1791 these geodetic operations had for the most part been undertaken on a scientific basis under the general direction of the Royal Society, and such success as they achieved owed much to Roy's personal energy and enthusiasm. Although he died in 1790, a year before the Ordnance Survey was set up, Roy can be regarded as the father of the Ordnance Survey of Great Britain. On his death it looked as if the idea of creating a National Survey might be shelved, but fortunately the Master General of the Ordnance of the day, the third Duke of Richmond, had taken a great interest in Roy and was convinced of the importance of surveying to the extent that he had employed land surveyors of his own at Goodwood. In 1791 the Duke, his hand no doubt strengthened by the threat of an invasion from across the Channel, put the survey on an official basis under the Board of Ordnance and from that date the Ordnance Survey can be said to have existed.

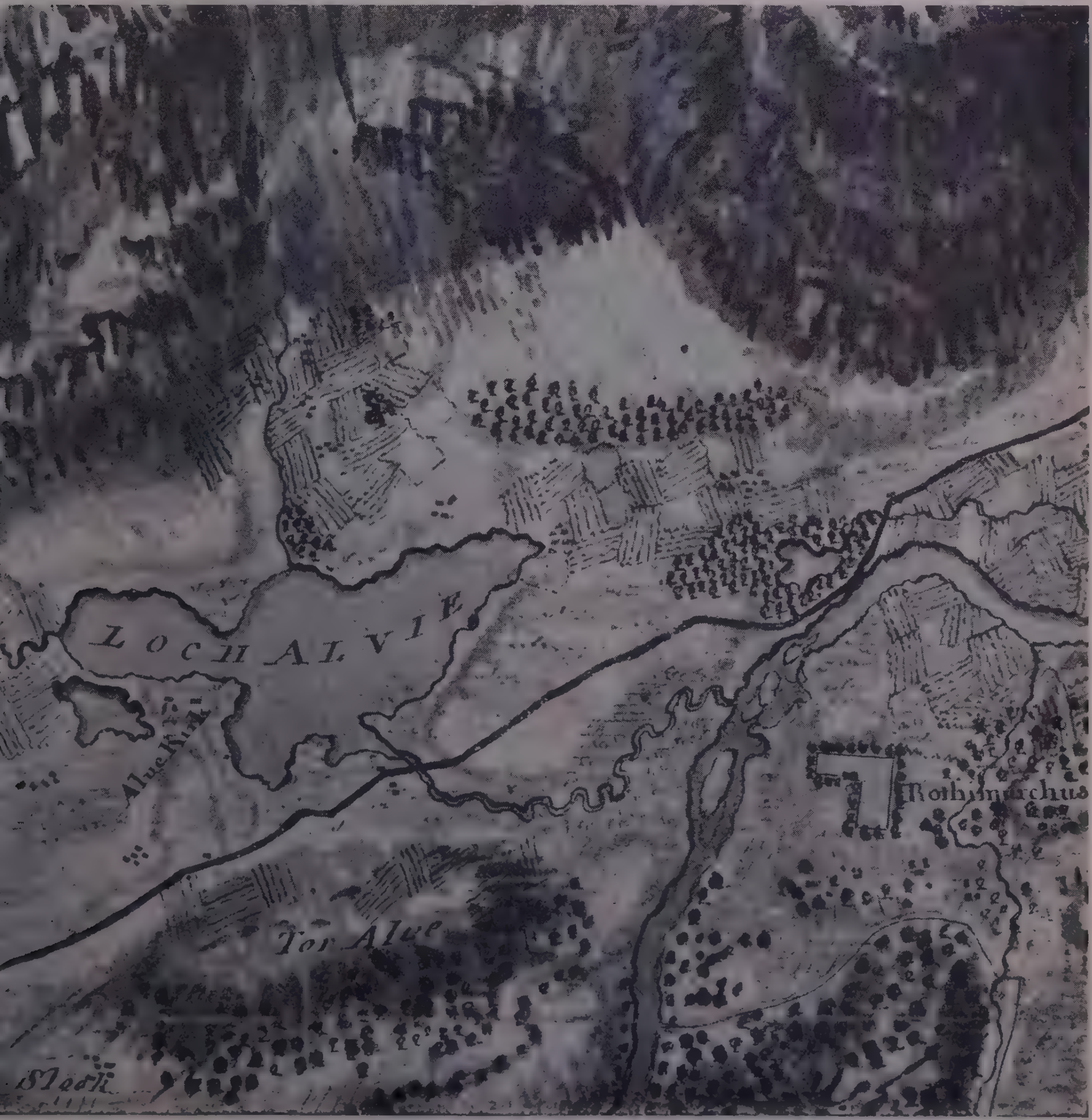
To begin with, the Department consisted of no more than a handful of surveyor-draughtsmen supported by a small number of officers and other ranks drawn from the Artillery and Engineers. Initially the task consisted of providing the essential control for the first systematic one-inch to one-mile survey of the country, and for the next thirty years the Department was actively engaged on both the triangulation and the one-inch to one-mile survey. These tasks would no doubt have been carried to completion but for the fact that in 1824 a Select Committee recommended that, as a matter of urgency, Ireland should be surveyed at a scale of six inches to the mile for valuation purposes and the Ordnance Survey was instructed to get on with the work with the least possible delay. As a result its resources were largely diverted to this work for the next twenty years. At this time most of England and Wales had been surveyed at the one-inch scale but Scotland and the six northern counties of England had not so far been touched.

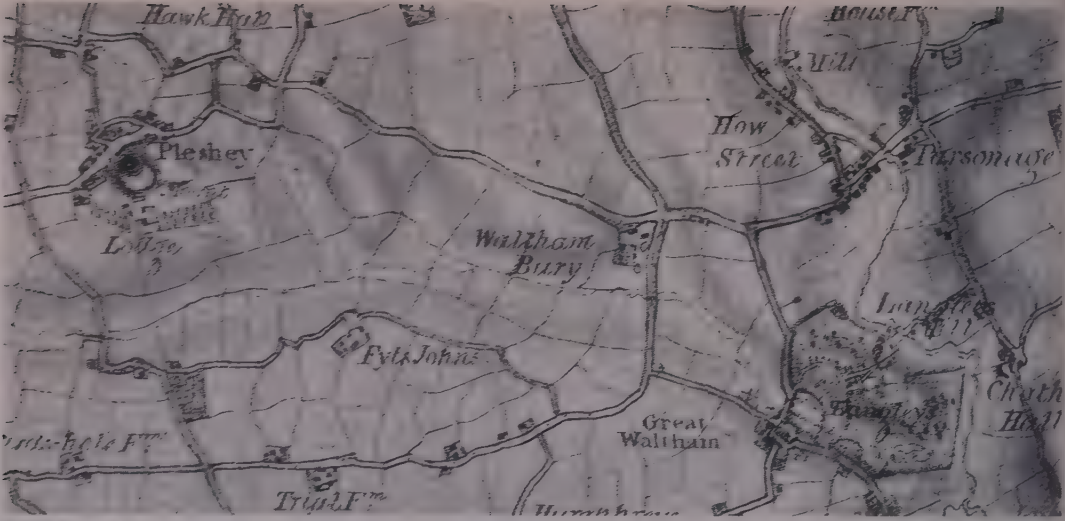
When the work was again taken up in England and Scotland, as a result of experience gained in Ireland it was decided that Scotland and the six northern counties of England should be surveyed at a scale of six inches to the mile and not at one inch to the mile.

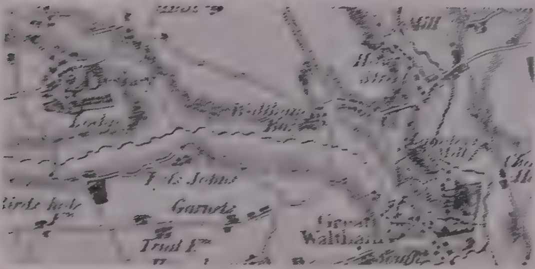
In the meantime the principal triangulation of Great Britain had been resumed in 1838 and was completed in 1852. This triangulation, bearing in mind the instruments available at the time, the difficulties of transportation and the length of the rays to be observed, was of a very high standard and was in fact to provide the control for the mapping of Great Britain for the next

A portion of the military survey of the Highlands carried out between 1747 and 1755. Though it was never published, this survey, in which General Roy as a young man played a prominent part, began the process which eventually led to the creation of the official Ordnance Survey

British Museum







British Museum

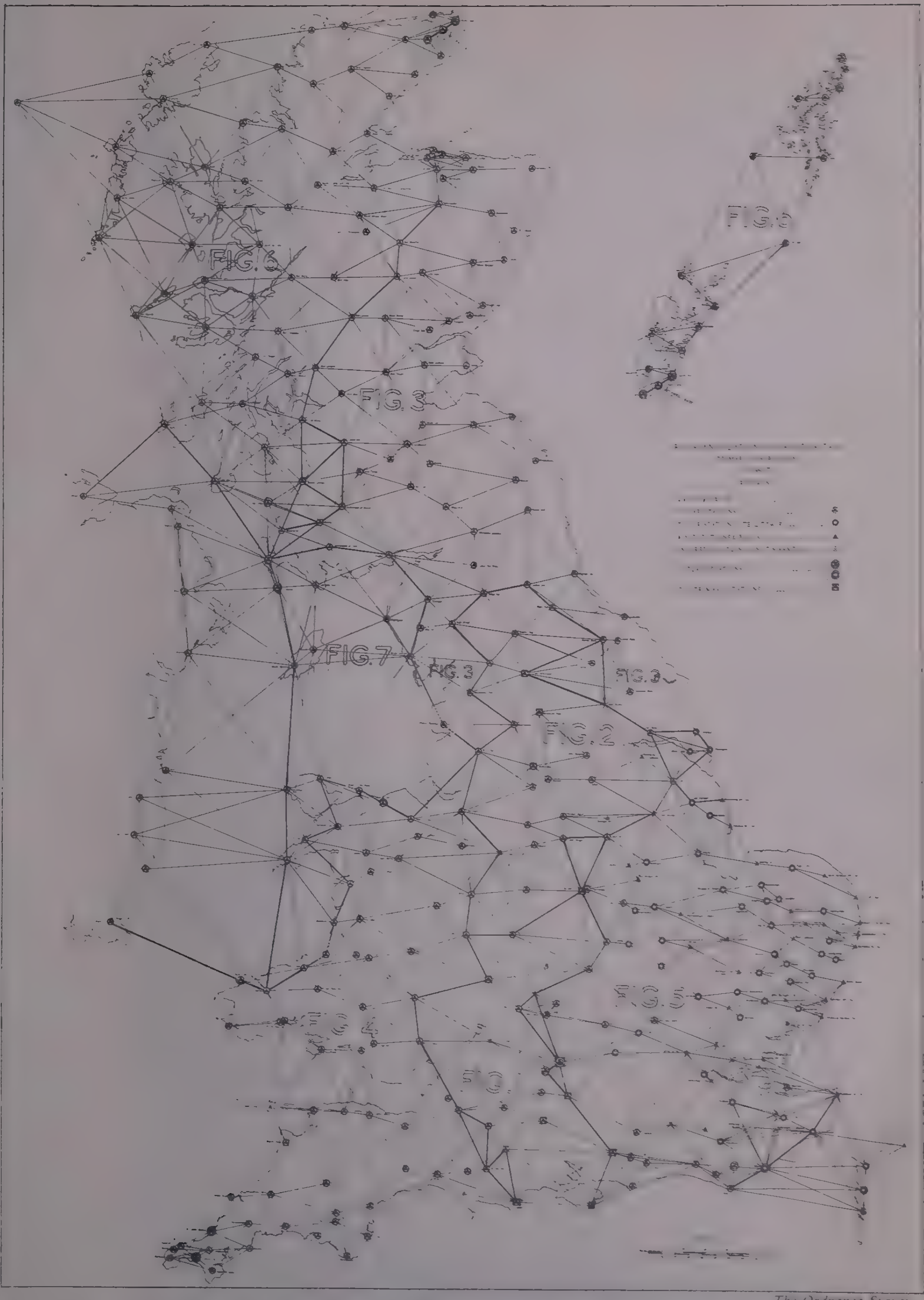
(*Above*) Part of the original drawing of the first survey (*c.* 1800) undertaken by the Ordnance Survey at a scale of two inches to one mile. Another extract (*left*) of the area, also from an original, shows the style of the first Ordnance Survey one-inch series

hundred years.

The six-inch survey of Scotland and the six northern counties of England was pursued until in 1853 the Government, under pressure from the public, sought the opinion of engineers, land-surveyors and others interested in Ordnance Survey plans, and as a result it was agreed that in all but mountainous and moorland areas the country should be mapped at a scale of 1: 2500 (about twenty-five inches to the mile). This was a very momentous decision as no other country in the world had, or for that matter has since, endeavoured to map such a high proportion of its area at such a large scale. It must be remembered that these maps were never intended to show property boundaries as such and could not therefore be strictly regarded as cadastral plans. After some opposition the recommendation regarding the 1: 2500 scale was finally accepted in 1858 and work at this scale initiated. The 1: 2500 survey was completed in 1895, some thirty-seven years after its commencement. Remembering the very laborious nature of the task, consisting in the main of measurements by chain on the ground with detail measured by offset from the chain lines, subsequently plotted in the office and finally checked again on the ground, the time taken reflects the greatest credit on those concerned.

Thus by 1895 the United Kingdom possessed a control system based on the principal triangulation and a series of maps covering the entire country which surpassed those of any other nation. For a number of reasons, of which war was by no means the least significant, both the control system and the maps were insufficiently maintained. The South African War, and to a greater extent the 1914-18 war, made heavy demands on the Department. From 1914 onwards work on the maintenance of United Kingdom mapping gradually came to a halt and all the Department's resources, even to the extent of establishing an overseas branch in France, were directed to the war effort. After the war the pressing need for economy reduced the strength of the Department to a point where it could do no more than maintain its one-inch and smaller-scale series, and endeavour to make good the backlog of revision of the 1: 2500 series caused by the war and to keep pace with the steadily increasing amount of building and road development.

By 1935 it was apparent that in many areas plans were so out of date that they could no longer be revised and some form of resurvey was essential. This meant going back to the control system



The Ordnance Survey

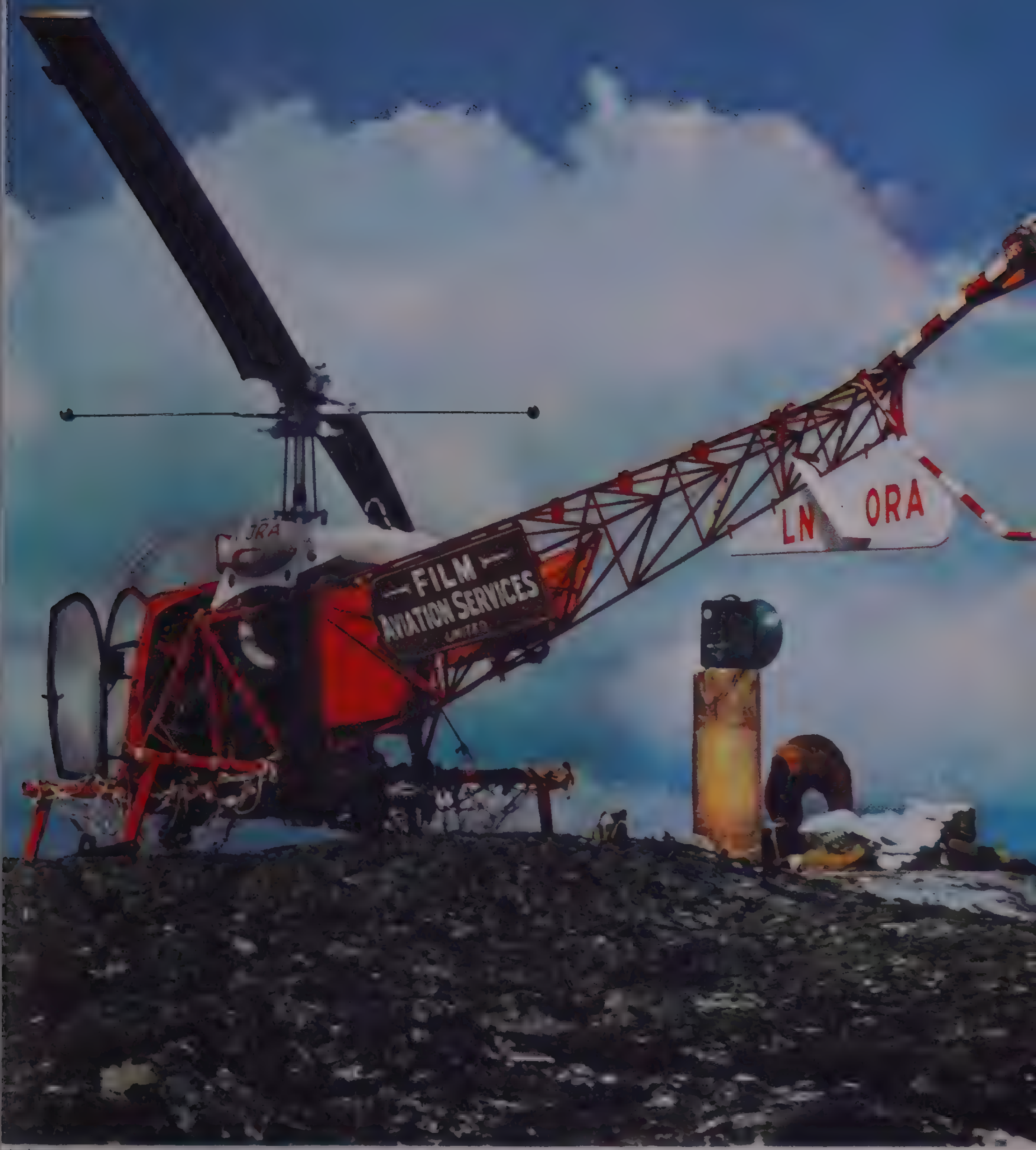
The primary triangulation shown in this diagram provides the framework for subsequent survey work. It consists of a series of triangles covering the country. The positions of the corner points of the triangles are computed from their horizontal angles, measured with a theodolite, and the length of side is obtained from a measured base. This primary triangulation is now being broken down into smaller triangles to give triangulation points four to five miles apart

which was by this time in many respects inadequate. In some cases buried triangulation marks could not be recovered and in others buildings carrying Ordnance Survey triangulation marks had disappeared. The immediate problem therefore was to carry out a new triangulation, and this was put in hand in 1935. Today, Great Britain is completely covered by a new primary triangulation which has been broken down to a secondary and tertiary triangulation over nine-tenths of the country. Once again Ordnance Survey surveyors have found themselves climbing almost every eminence of any significance throughout the country and enduring, often for weeks on end, the frustration of waiting for distant signals to become visible. Only recently a section observing Ben Nevis was faced with an unusual problem. In midsummer, when the top of Ben Nevis is clear of snow, a ray to a neighbouring peak, Beinn Na Cucaig, is normally open, but when the section observed from Ben Nevis in May the ray was blocked by a snow cornice overhanging a 1000-foot precipice. Two members of the section started to clear a channel through the snow, but without ropes could not go out on the overhang. Fortunately, a cooperative climber fully equipped with ropes arrived on the top of the mountain, and with the aid of one of his ropes a channel about thirty feet long and six feet deep was cleared through the snow. Once again "the light got through". Naturally the task was easier for these modern surveyors than for their predecessors 100 years before; theodolites were lighter, easier to read and in every way superior to those of the past. Better signal lamps were available and, perhaps most important of all, the improvements in transport facilities made the whole operation quicker and easier to control. On some of the higher and more remote mountains remains have been found of the encampments occupied by surveyors on the first triangulation. Such remains exist on Ben Hutig, Creach Bheinn, Cader Idris, Ben Kibreck, Jura and Clisham.

In order that the retriangulation should, it is hoped, never have to be repeated, the majority of the triangulation points have been marked by concrete pillars. To date over 6000 of these have been erected, and although they cannot be

A party preparing to observe from a triangulation pillar on St Kilda. Observations were made at night to lamps mounted on five triangulation pillars on the Outer Hebrides. The lengths of the rays varied from fifty to seventy-five miles. The party made use of wireless communication

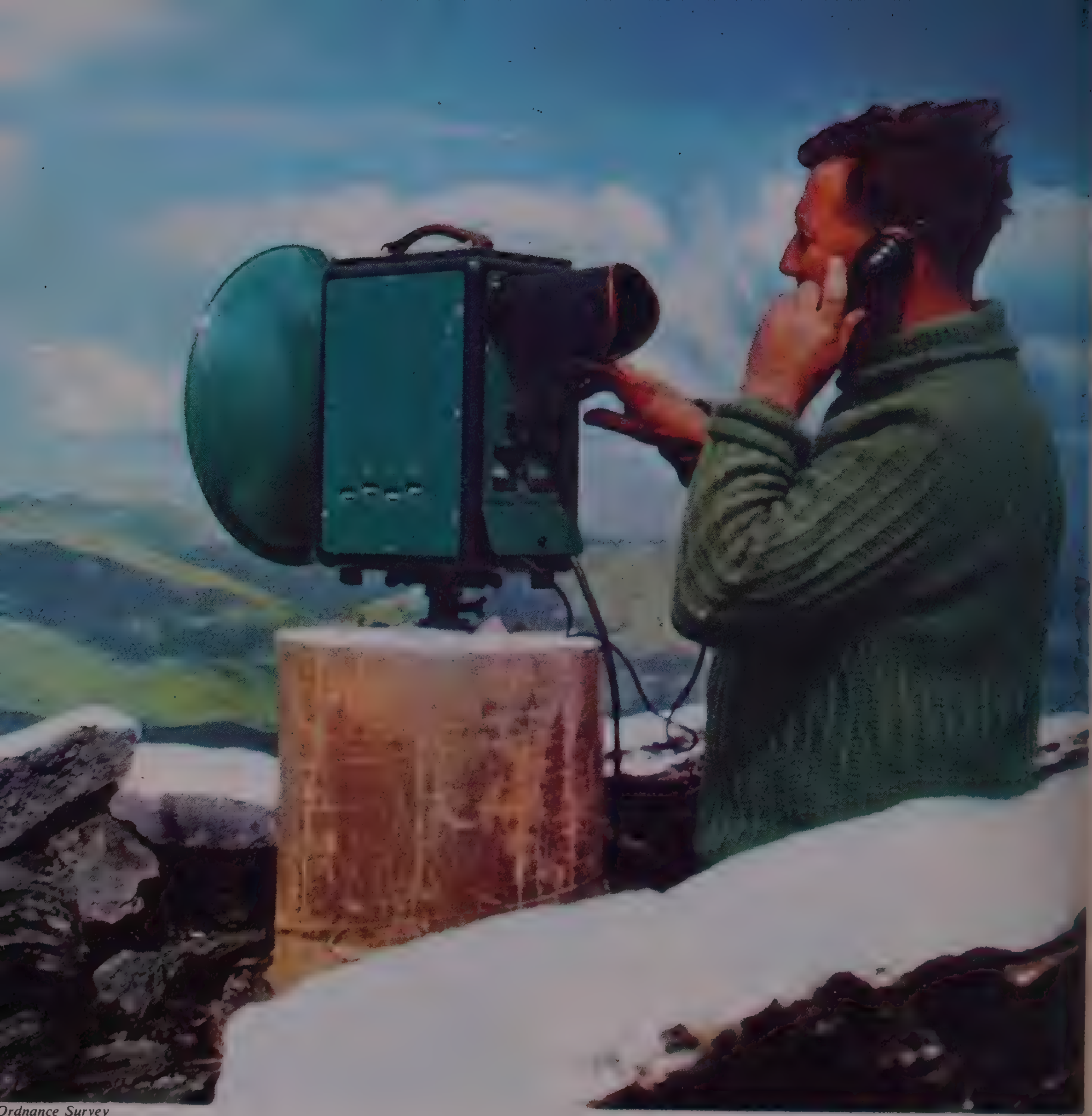
he Ordnance Survey



dachrome

The Ordnance

A helicopter delivering surveying instruments at a triangulation point on top of a mountain. Each point has to be visited twice: first by the two men who erect the pillar; secondly by the observation party. In inaccessible places prefabricated cylindrical concrete pillars are used, like this one, to ensure that they can be erected in a day. Without the helicopter the job might take a week



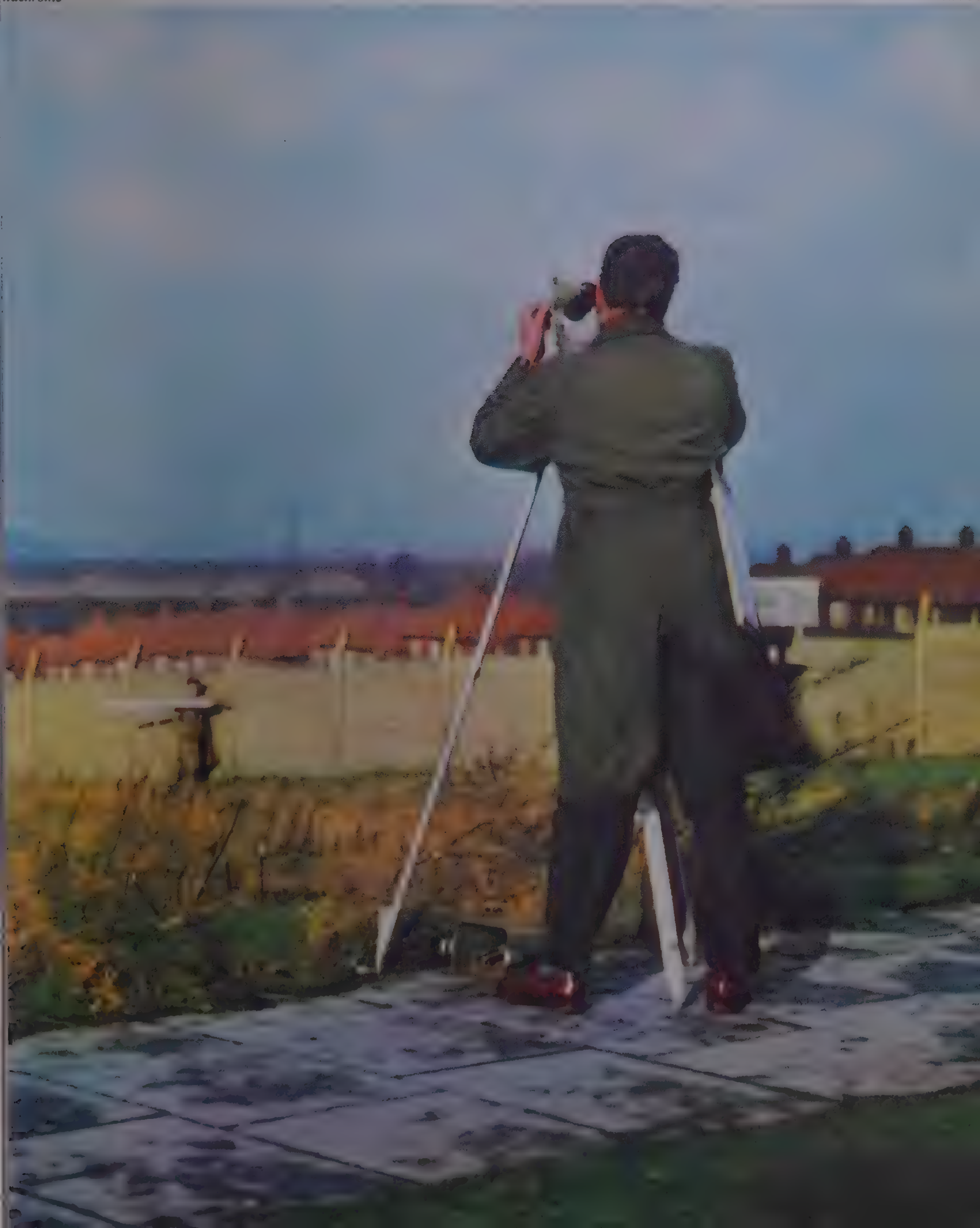
Ordnance Survey

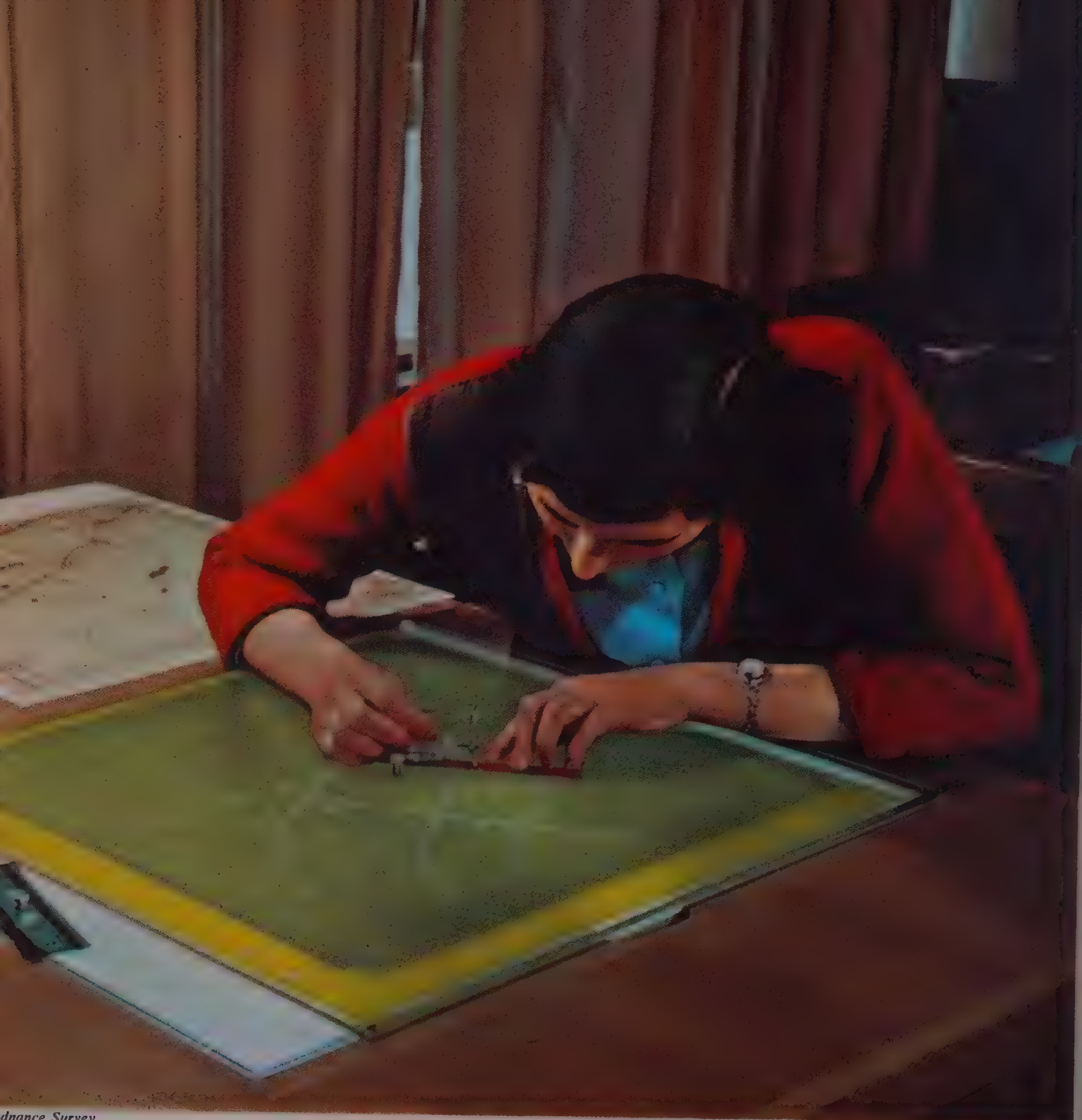
Kodachrome

A tellurometer being operated in Scotland to measure directly the distance from one triangulation pillar to another. The tellurometer was invented and manufactured in South Africa; it determines distances electronically by measuring the time taken for a radio micro-wave to travel between a master instrument and a remote instrument which radiates the wave back again. Knowing the speed of the radio wave, the distance between the two instruments can be calculated. Since 1957, the Ordnance Survey has been using the tellurometer to advantage as a control for field and air surveys. A measurement which used to take four weeks is now completed in a day

A tacheometer in use in the Bexley Heath area. For some years now the Ordnance Survey has been making increasing use of tacheometers to provide the local framework for the 1 : 1250 resurvey. This was done before by measurements with a chain, a slower method dating back to the early years of the Ordnance Survey. The tacheometer measures both horizontal angles and distances and thus enables the exact relative position of points of detail to be fixed and plotted

tachrome *John To*





dnance Survey

Kodachrome

A draughtswoman scribing a map. The work of the field surveyor is transferred photographically from the field document to a sheet of glass which has been covered with a translucent coating, producing an image in reverse on the glass. The task of the draughtswoman is to cut the coating following the image of the surveyed detail so as to leave clear glass where the image lay. A negative of the map is thus produced and this can be printed down onto a printing plate. The scribing cutters are made in Ordnance Survey workshops and include double cutters for roads and railways. These cutters can be fixed in two types of tool-holder; one, for straight-line work, in which the cutter is rigid, as shown here, and the other, in which the cutter swivels, for freehand lines like streams and contours. The advantage of this method over drawing lies in its greater speed and consistency in the gauge and density of the line described as things of beauty, nevertheless it is hoped that they will be accepted as offering the possibility of saving posterity the very considerable expense involved in a retriangulation. In some cases it has been possible to use local stone instead of concrete, but the extra cost has severely limited the instances in which this could be done.

An Interdepartmental Committee set up in 1935 under the chairmanship of Lord Davidson, and known as the Davidson Committee, went into the question of the future policy of the Ordnance Survey. In its final report published in 1938 it recommended, briefly, that steps should be taken to put the National Survey on a proper footing, and that thereafter it should be maintained so that the need for resurvey in the future would seldom arise. Unfortunately, just as a start had been made in recruiting the personnel to carry out these recommendations, the 1939–45 war broke out and once again the work of mapping Great Britain came to a standstill.

Throughout its history and until just before the war the Ordnance Survey had been largely staffed by serving Royal Engineers and ex Royal Engineers who had completed twenty-one years in the Army and had been kept on in a civilian capacity. From 1935 the Department increased its recruitment of civilians so as to build up the staff necessary to carry out the recommendations of the Davidson Committee. When war started practically all the resources of the Department were put at the disposal of the War Office. Both serving personnel and civilians were progressively drawn into military survey units and both those in units and those who remained in the Department contributed to the enormous mapping task created by the war. Faced with the prospect of providing maps in quantity of almost anywhere in the world, the War Office needed all the mapping resources it could possibly lay its hands on. As the oldest mapping organization in the United Kingdom, the Ordnance Survey can take some pride in the fact that, even before Dunkirk, French staff officers were anxious to obtain British maps, apparently preferring them to their own. Even more impressive was the mammoth task of providing 120,000,000 maps for the Normandy invasion. Many of these maps were compiled, drawn and printed by the Ordnance Survey.

As the war progressed and the country suffered increasing damage from enemy air attacks, the immediate post-war need for up-to-date mapping was realized. In 1944 the Government agreed that after the war all the major towns in Great Britain should be resurveyed at a scale of 1 : 1250,

The Ordnance Survey has twenty-three air-survey plotting-machines for plotting maps from air-photographs. The surveyor views two pictures stereoscopically, and with the aid of a pantograph draws the detail and contours from this three-dimensional image to the scale that is required

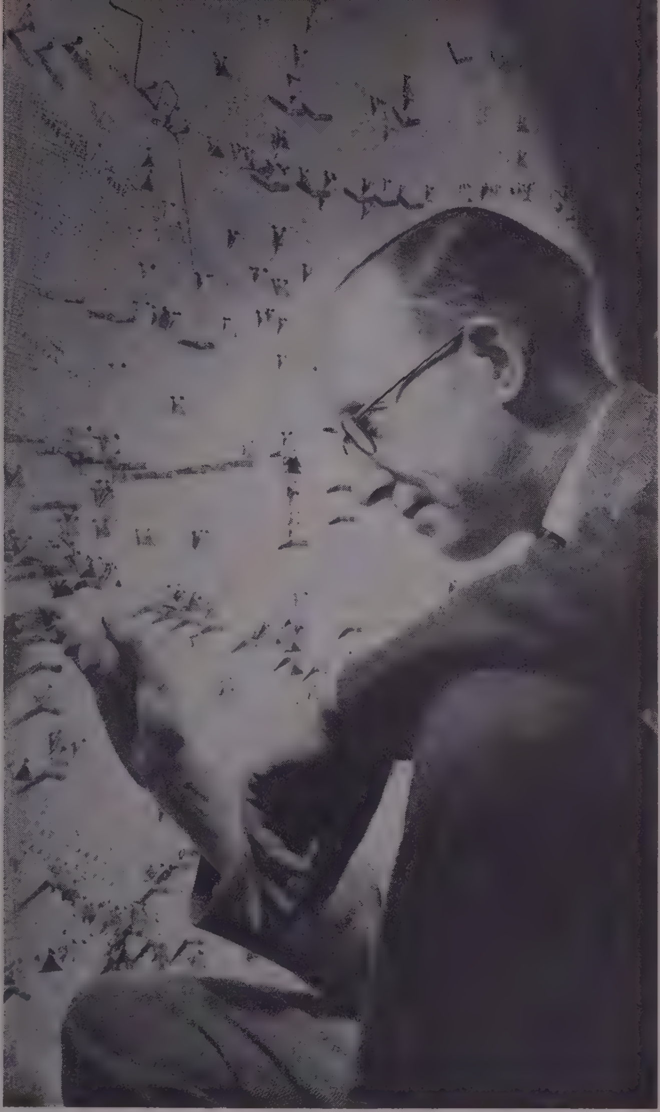
eystone

For the motorist, an Ordnance Survey map is a boon; for those who leave the beaten track, like the intent group (*above*) of hikers from the Outward Bound Mountain School, it is essential. (*Below*) The Automobile Association last year supplied its members with 1,133,000 individually planned itineraries, put together from 8000 different route-sheets based on the Ordnance Survey

y courtesy of the Automobile Association

roughly fifty inches to the mile. For the remainder of the country the old 1:2500 series, and in mountainous and moorland country the six-inch series, were to be reconstituted and revised on National instead of County sheet lines. This therefore has been the main task of the Department since the end of the war. As soon as demobilization got under way, the Department began recruiting and training on a large scale in order to increase its strength from the 2000 or so before the war to over 4000. Training presented a very real problem, as it must be remembered that the Department was embarking on a programme which in its size and technical complexity had not been attempted since the beginning of the 19th century. It is greatly to the credit of my predecessors that within a comparatively short time programmes were under way, and today, twelve years later, the end of the resurvey of some forty thousand 1:1250 plans covering the major towns is in sight and the revision of the 1:2500 series is going ahead with increasing momentum.

Initially the methods employed for the resurvey were not vastly different from those used in the original 19th-century survey, but gradually, as new instruments and equipment became available, more economical methods have been introduced, including the increasing use of air survey.



New Scotland Yard

A civil employee of the Map Room at New Scotland Yard studies the accident map, made up of Ordnance Survey sheets. Crimes are plotted on similar maps. In both cases the pattern of incidence helps prevention

Today the use of a chain to provide the final framework on which to hang the roads, houses, and mass of other detail appearing on the plan is gradually disappearing. In its place the tacheometer, a simple instrument for obtaining distances, and the air-photo plotting-machine are performing the same task more economically.

Other innovations are also being employed. In recent years helicopters have been used to great advantage in conveying men and material to inaccessible mountain-peaks for pillar building. A new electronic distance-measuring device known as a tellurometer, designed and manufactured in South Africa, which promises the greatest advance in survey-methods for many years, has been taken into use, although the Department's programmes are too far advanced for the fullest benefit to be gained. After the war the Department was largely responsible for introducing a method of computing control-points from measurements taken from air-photographs in a machine known as a stereo-comparator; a method which is steadily gaining wider recognition abroad.

In all its other activities the Department has kept abreast of new developments. Over the years perhaps the greatest change has taken place in the mediums used in the fair drawing of Ordnance Survey maps. The maps were originally engraved on copper; later they were drawn on paper which was subsequently mounted on zinc; later still they were drawn on enamel-coated plates; today many of them are scribed on glass. It is not without regret that the Department has, in the interests of economy, all but given up the writing of names, which in almost all cases are now printed, cut out and then stuck down on the final drawing. Gone is the very special skill in the writing of names of the old Ordnance Survey draughtsman who could so often boast of his ability to write the Lord's Prayer in the space covered by a threepenny bit.

These changes have robbed the one-inch and smaller-scale maps of some of their artistic character, a loss for which modern printing equipment and improved techniques have only partly compensated. Against this, in recent years the Department has reintroduced in a few of its products, in particular in some sheets of the one-inch Tourist Series, a system of hill-shading to depict relief. Where the relief, as in the Lake District, the Highlands and Snowdonia, is of such a dramatic nature that it cannot be adequately portrayed by contours even when these are supplemented by a system of layers, hill-shading, when skilfully applied, can be used to advantage. Its success depends largely on the skill of the draughtsman concerned, even though his task is made easier by the stereoscopic examination of air-photographs of the area.

No account of the Ordnance Survey would be complete without mention of its archaeological activities. Its special maps of Roman Britain, Monastic Britain, and so on, are reasonably well known, but it may not be generally recognized that by showing archaeological information on its large-scale plans the Ordnance Survey possesses a geographical record of the archaeology of Great Britain which has no counterpart in the world and which is the envy of foreign archaeologists. No doubt from time to time plan users are puzzled, if not irritated, by the wealth of archaeological information appearing on some plans, but at a time when the face of the country is changing with such rapidity as at present, the need to record archaeological sites is greater than ever. On occasion even I have found myself sharing the feelings of such plan users. Only recently I was amused to find detail appearing on a Newcastle-on-Tyne 1: 1250 plan which was described as "Temporary Crossings". It appears that these crossings of the Vallum adjoining Hadrian's Wall were temporary some 1500 years ago!

The position therefore is that the Ordnance Survey is going ahead with rebuilding the edifice which, through lack of essential maintenance, had fallen into disrepair earlier in this century. It will be many years before the position reached at the end of the 19th century is recovered, but comfort can be drawn from the fact that every effort is being made to avoid the survey becoming so out of date in the future that the present prodigious effort will have to be repeated. I have already described the way in which the triangulation has been marked for posterity. In addition, in all areas where development is likely, small teams of surveyors, known as Continuous Revisers, are left in the area after it has been surveyed so that new developments can be added to the plans as they take place.

The Ordnance Survey is also carrying out a resurvey at a scale of six inches to the mile of the Highlands where the original survey was known to be weak, particularly in regard to the contours and rock features. This work is entirely dependent on air-survey methods, which are particularly well suited to the purpose. Some anxiety was felt in 1958 that the survey might be held up for want of air-photographs owing to the very poor summer but, thanks to the glorious weather in 1959, the situation has already been retrieved.

Since the war the Sixth Edition one-inch to one-mile Series has been completely revised and replaced by the Seventh Series, the last sheets of which will be published by 1961. The revision material for this series is being used in the production of provisional editions of the 1: 25,000 and six-inches to one-mile series. These provisional series will eventually be replaced by regular series based on the work produced by the 1: 1250 resurvey and 1: 2500 overhaul programmes.

Finally, some mention must be made of the debt owed by the Ordnance Survey to its staff, which was largely made up of soldiers until 1935 and since the war almost entirely of civilians. The devotion to the duty of producing maps of their country shown by these men and women, whether draughtsmen, surveyors or printers, is something of which we in Britain can well be proud.

Modern Survey-Methods

by A. C. STEPHENSON

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"There are no more major topographical discoveries to be made in this world." "The last major voyage of exploration has been made." Statements like these have often been heard in the last few years and have usually been followed up by some such comment as "All that remains now is to fill in the details of the map to further the general development of the country."

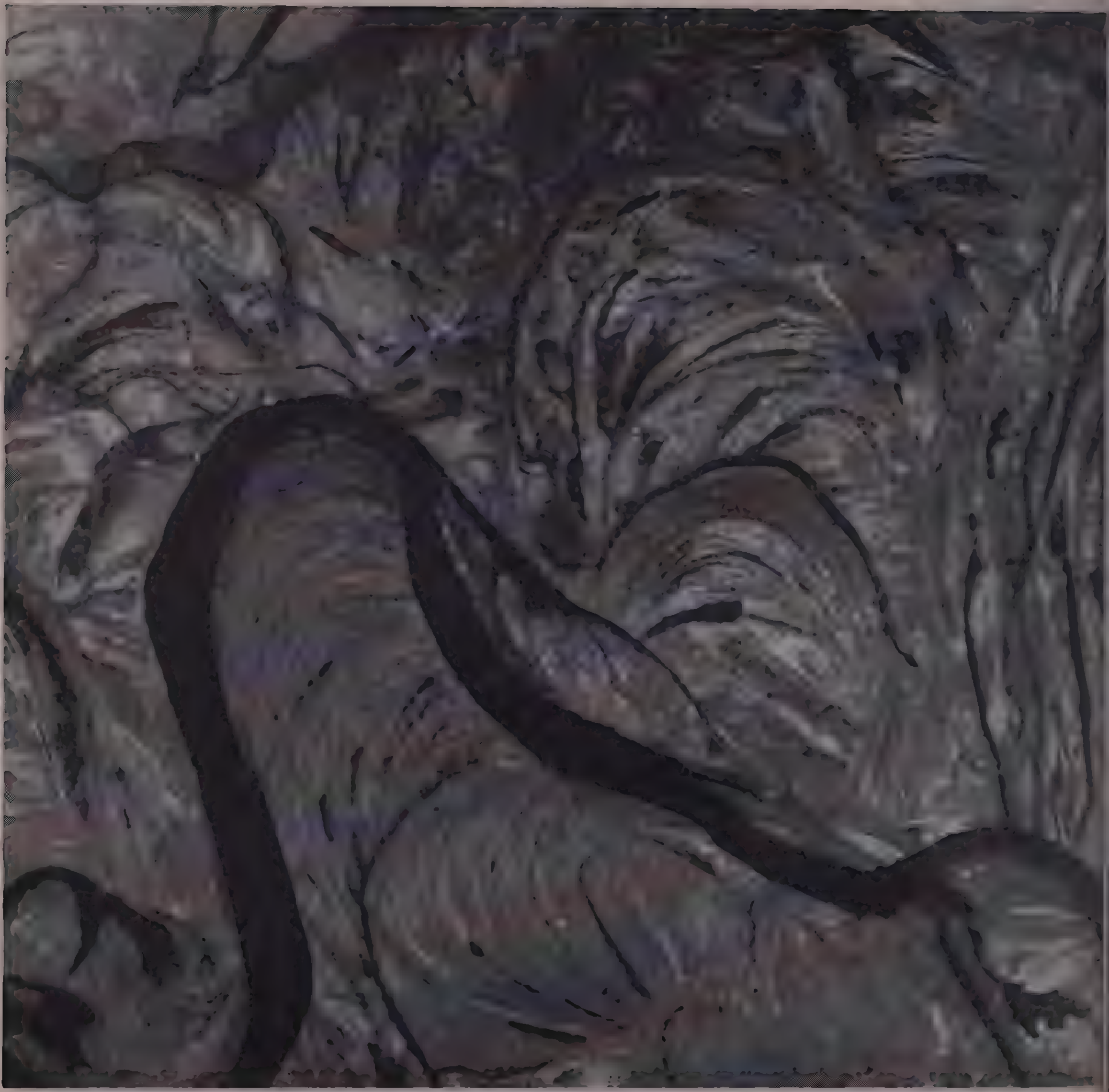
Between these two stages, the initial exploratory survey of an area and its detailed mapping, there is a tremendous gap, and the state of mapping in most countries of the world lies somewhere in the gap. This tallies with the fact that less than 20 per cent of the world's land-area has been topographically mapped, that is on scales similar to the Ordnance Survey one inch to one mile (1: 63,360) and a further 25 per cent has only been covered by maps on scales of a quarter of an inch to one mile (about 1: 250,000) or less.

Generally speaking, one can say that the more precise maps are of those areas where the standard of civilization is high and the economic development has been great, or in the less populated areas where the administration has had the foresight to realize that all development is primarily dependent on a good map. Present-day India, for example, owes a great debt to the original Survey of India, which made the basic maps of the whole country. But the old way is no longer quick enough. Mankind today, although concentrated for the most part in certain highly developed areas, can only survive by developing the underdeveloped and unexplored areas of the world, and this means that maps are required urgently in areas where the conventional gradual building up of a survey has not been possible. Detailed maps, for example, have been called for in isolated parts of Arctic Canada, and in areas where large engineering works are planned such as the Owen Falls, the Kariba Gorge and the proposed Volta River scheme. Where the presence of oil is suspected, whether it be in the middle of a desert or under the sea, maps are required so that geological and geophysical information can be plotted and an assessment made.

Is there any means by which these special maps can be made more quickly than in the past and at the same time be of such an accuracy that they will fit into the ultimate survey of the country should it be necessary? The answer is yes, and in what follows I propose to show how new methods are being used to produce maps for special purposes.

Special maps include geological maps used by oil companies, land-use surveys used by planning authorities, large-scale contoured plans used by civil engineers for planning hydro-electric projects and irrigation schemes, and route maps or profiles for projected highways or for carrying pylons for high-tension cables.

There is a twofold task, then: first, to produce a basic map as quickly as possible, if one does not already exist; and secondly to add the special information to this map. The particular problem in the first part is to try to place the basic map of an isolated area in its correct position and orientation so that it fits into the final map that will one day incorporate the smaller area. This appears to be reversing the surveyor's golden rule of working from the whole to the part, but in fact modern electronic methods have made it possible without breaking the rule. The Yellowknife area in the North-West Territories of Canada, which suddenly became a centre of tremendous activity, lies in a region where for hundreds of miles around there is nothing but lakes and tree-covered country, for which the existing 1 : 250,000 maps made from air-photographs are amply sufficient. In the normal course of events the trigonometrical survey from Alberta would have gradually been extended by conventional ground-survey methods using triangles of twenty- or thirty-mile sides until the Yellowknife area was tied in to the main Canadian network, and then the detailed survey would have followed. What happened instead was that a giant triangulation scheme using sides of some 200 miles in length was observed by airborne electronic measurements, thus linking up the old area to the new, so that its absolute position and orientation was known and the final detailed survey could be



Royal Air Force photograph, Crown copyright reserved

An air-photograph of the kind used extensively in modern geological surveys. This shows the meanders of the Zambesi River. The great serpentine carvings across the surface of the ground mark previous courses of the river through the plain and the limits of its extensive floodings

made once and for all in its true position.

The method used, known as Shoran, is one of the many methods based on the development of wartime navigational techniques, and I will refer to it again later. Similar principles are adopted in ground surveys where use is made of the tellurometer, which is capable of measuring lengths of twenty to seventy miles with remarkable accuracy in a very short time.

Both the above techniques are used extensively for providing the triangulation or traverses that form the basic network in any survey. The next stage, the breaking down of the network and the filling in of detail, has been speeded up by vertical air-photographs, amongst other things.

The second part of our twofold problem is to add the special information to the basic maps. This involves some principles which may not be appreciated at first sight. It is no good recording from an aircraft the profile of a particular section of country if the exact location of that section is not known. It is equally useless to have an air-photograph on which an important geological fault-structure is shown by a marked change in the vegetational growth if that particular photograph cannot be accurately identified on the map. What must be appreciated is that when the various new methods that are being used for obtaining airborne magnetic or geophysical data, or for obtaining ground profiles by "echo sounding" from the air, are considered, all the new information must be related to recognizable ground features which have already been or can be mapped.

The most important of the new survey-methods are undoubtedly those based upon some form of electronics. This applies particularly to the measurement of distances by means of recording the transit-time of electromagnetic waves passing from one point to another. These waves are sent out in pulses by means of a transmitter and a special aerial, in a direction that is controlled by a reflector or dish. In some methods the rays merely hit an obstruction, such as the surface of the earth or a navigational hazard, and are returned to be picked up by the special receiving aerial and transferred by various means either to a cathode-ray tube or to a chart. In other instruments the outgoing waves are directed to a receiver-cum-transmitter and the "reflected" waves are actually transmitted back.

These instruments enable such measurements to be made as the distance of the ground vertically below an aircraft (Airborne Profile Recorder); the direct slope distance between a transmitter and a remote station (the tellurometer); and the distance between a moving airborne transmitter and two ground beacon-transmitters (Shoran).

Echo sounders have been in use for many years for determining the depth of water, but the more sensitive types made today can be used for more than that, for not only do they give a reflection from the bed of an estuary, but further reflections can be detected from bed-rock, and the layers underlying the sediment. This provides information previously only obtained by boring and taking sample cores, and is of immense value to the engineer.

The Airborne Profile Recorder works in a similar way in that it transmits radar waves down a narrow beam one degree wide, which are reflected from the ground and received back into the aircraft. The length of time that this return journey takes is translated into feet, knowing the speed at which the particular electromagnetic waves travel, and the distance or height of the aircraft above the ground is recorded on a continuously moving chart. As the transmitter is working all the time, the results are continuous and appear therefore as a wavy line which to all intents and purposes represents the profile of the ground over which the aircraft has flown. However, it must not be assumed that the result is a profile accurate enough for engineers or geologists to work from. If the aircraft suddenly drops a hundred feet the profile will record a similar change, so the A.P.R. record must be checked against any relative change in flying height. This is done by recording simultaneously and electronically, by a hypsometer, the changes in height with respect to a constant pressure surface. Even when this variation in aircraft height is taken into account, there is still the problem of knowing the precise height above datum at which the aircraft is flying if the absolute levels of the profile are required. Complete accuracy here is impossible, but a very good approximation can be made with the aid of all the meteorological information and ground checks available.

A reminder is necessary here that even with this information it is still not known what precise section of ground the profile represents. If the area has been mapped and the pilot can fly from point A to D via points B and C, all of which he can identify on the ground, then the profile can be located. In areas that have not been mapped the profile must be related to air-photographs, and this is done by directing a 35-mm. ciné-camera down the centre of the radar beam and recording photographically the exact line over which the profile was recorded. This 35-mm. strip of photographs is in its turn related to the vertical photographs which are taken at the same time and which form the basis of the final map. These profiles can be used in various ways. If a new road is projected in an entirely unsurveyed area, profiles can be made along the alternative possible routes and the final location chosen with little or no ground control.

Perhaps the most important use of the A.P.R. in the future will be to provide height-control points to enable a large area to be contoured from air-photographs with the absolute minimum of height control fixed on the ground. If from certain key control points whose heights are known (say the four corners of a square with

fifty- to hundred-mile sides) profiles are recorded and then further cross-lines are flown to and from identified points on the sides of the square, a large number of heights can be computed and located on the vertical photographs, which will enable a fairly closely contoured map to be made. In an area where development depends on communications and possibly irrigation a contoured map is the first essential, and with the aid of A.P.R. such a map can be made quickly, without waiting for lengthy ground surveys to be made.

In an entirely different sphere—glaciological studies in the Antarctic—the same method can be used and is in fact the only method for contouring areas a great distance from any known height such as mean sea-level or coastal mountains.

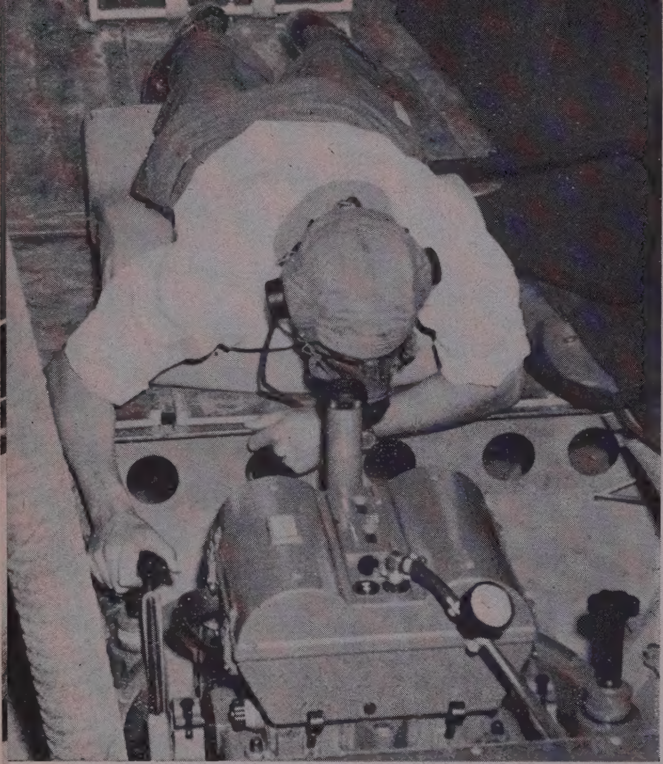
Mapmaking of all kinds has always consisted basically of measuring distances on the ground and differences in direction. So far no alternative has been produced to the theodolite for the precise measurement of horizontal angles, but the measurement of distance has been vastly speeded up by new methods. Long distances such as the sides of the triangles of a control triangulation have usually been computed trigonometrically, making use of one precisely measured side and all the observed angles. Now that precise distances can be measured much more easily the tendency will be to use measured sides much more than computed lengths.

The new methods entail the measurement of the time taken to transmit electromagnetic waves or light waves to a distant station and, knowing the speed of travel of these waves, computing the distance. The usual practice is to get a reflection from the other end either by retransmission or mirrors and measure the time taken for the double distance. Allowances have to be made for the atmospheric conditions at the time and, since the distance recorded is the straight-line distance between the two points, the difference in height must be known approximately so that the true horizontal distance can be computed.

For measuring lengths varying from five miles to a hundred miles (although it was designed primarily for distances of twenty to forty miles) the most useful instrument is the tellurometer. This consists of a transmitter and receiver in a box not much larger than a theodolite and just as portable. A battery and power-pack are also required. This equipment enables radio microwaves of 10-cm. wavelength to be transmitted and similar equipment at the other end of

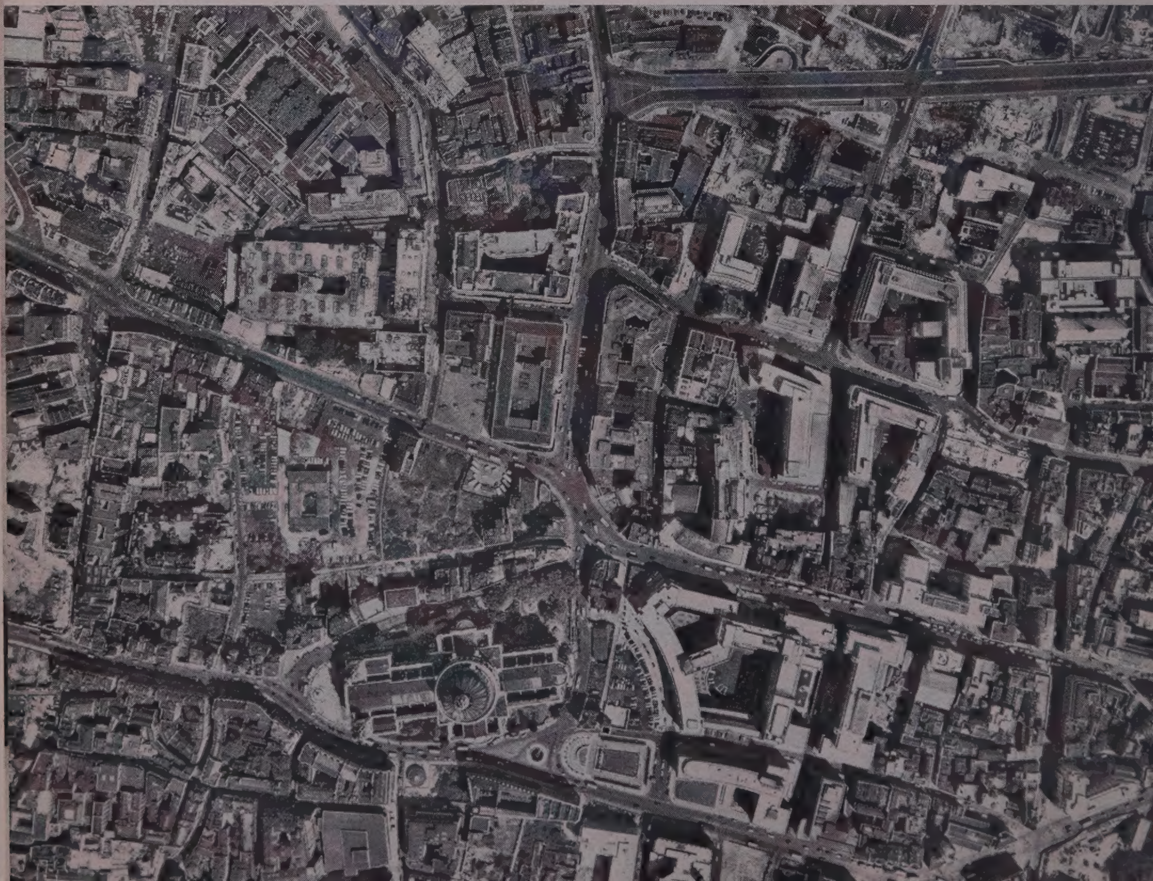
Geologists are among those who rely on modern survey-methods, and the finding and exploitation of the earth's hidden resources, such as oil, depend on the geologist and his accurate maps. (*Left*) An American research geologist adds important data to a map, using a magnifying viewer. (*Below*) A similar map; they are drawn from the composite picture produced by air-photographs

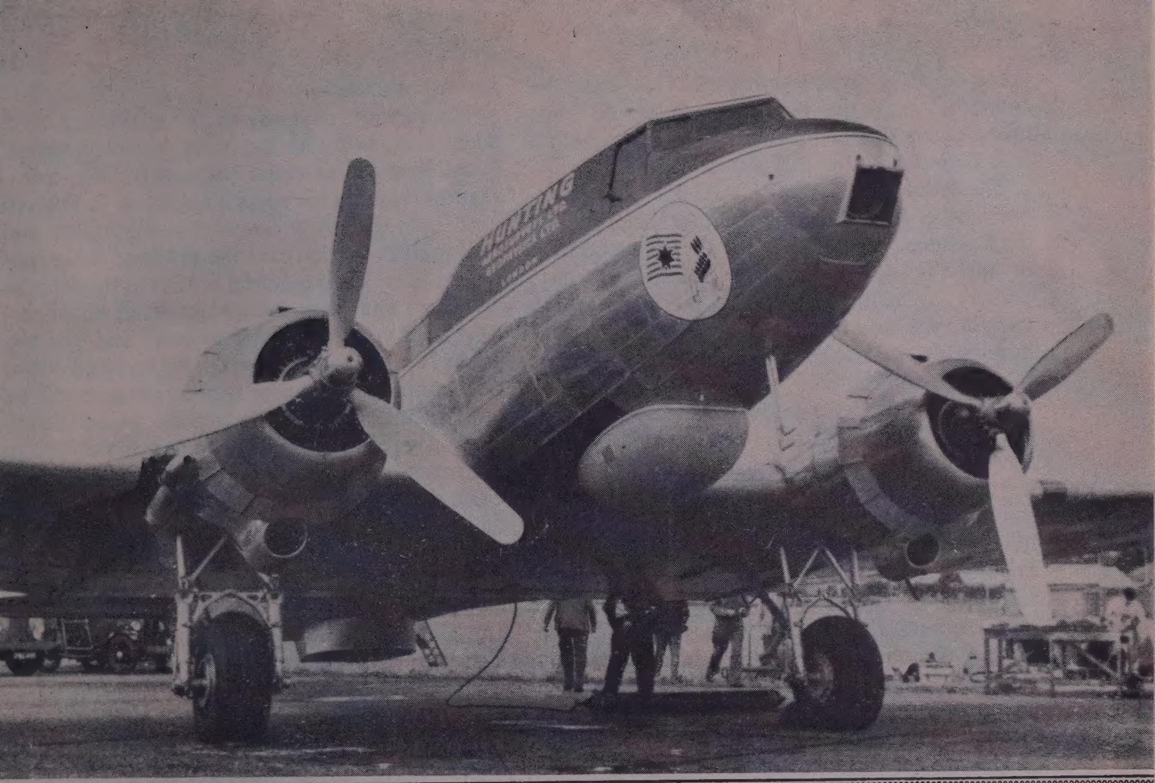
By courtesy of Hunting Surveys Ltd

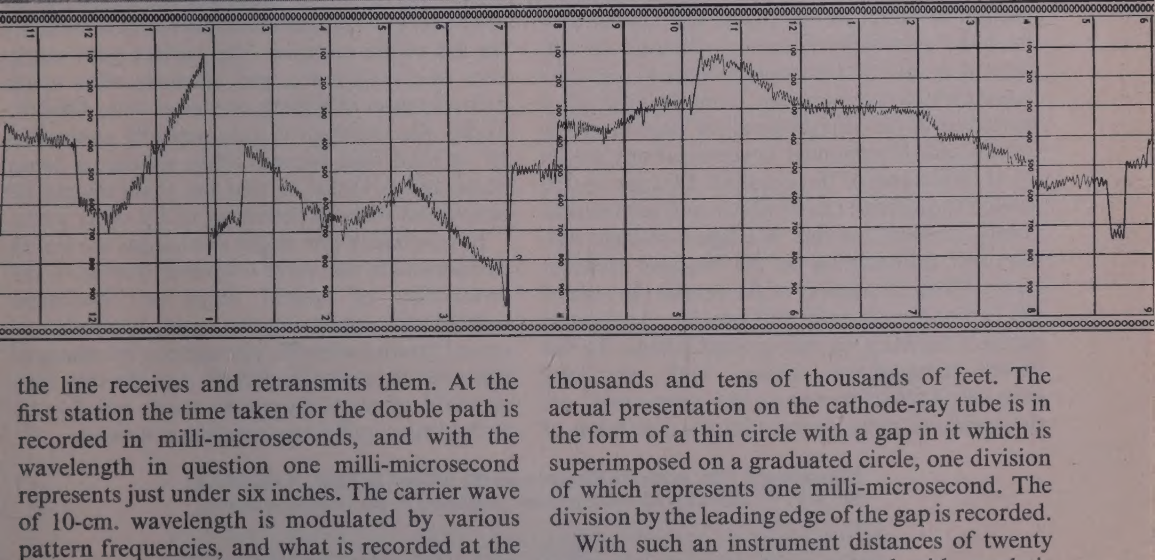


(Left) A Swiss camera designed to take air-photographs from high altitudes is the Wild R.C.5, which is shown here in position in the floor of an aircraft. The operator is looking down the camera's overlap sight, by which he adjusts the amount of overlap from one picture to the next (normally 60 per cent). His right hand is on the knob that controls the fore and aft levelling of the camera. A navigator lies near him, looking down a tracking sight which helps him to bring the aircraft into the exact line of flight needed for the photographic run. *(Below)* The St Paul's area of central London taken from 3450 feet with a Wild R.C.5 camera; an 8¼-inch lens was used on a 7-inch-square negative; the scale that results is 1:5018. *(Opposite)* The Airborne Profile Recorder, seen here beneath the belly of the aircraft, draws the contour of the land over which it is flown, using the reflection of radar waves to show the continually changing distance between aircraft and earth, and a hypsometer ensures that all variations from level flight will be noted. The chart shows an A.P.R. contour. A Doppler Navigator, the big round protuberance underneath the nose, helps keep the aircraft on its course

All four illustrations by courtesy of Hunting Surveys Lt







the line receives and retransmits them. At the first station the time taken for the double path is recorded in milli-microseconds, and with the wavelength in question one milli-microsecond represents just under six inches. The carrier wave of 10-cm. wavelength is modulated by various pattern frequencies, and what is recorded at the master station is the phase delay, the value of which represents the incomplete portion of that particular wavelength. If in addition the total number of complete wavelengths can be determined then the whole distance can be computed. Frequency patterns are varied by the use of different crystals, and a comparison of the phase readings of the different patterns enables the total distance to be recorded in units of tens, hundreds, thousands and tens of thousands of feet. The actual presentation on the cathode-ray tube is in the form of a thin circle with a gap in it which is superimposed on a graduated circle, one division of which represents one milli-microsecond. The division by the leading edge of the gap is recorded.

With such an instrument distances of twenty to forty miles can be measured with geodetic accuracy in a very short time indeed. The ray should be a visual one, but light rain or mist does not hinder the work. Orientation has not got to be very precise and is accomplished merely by swinging the instrument until a maximum signal is received from the other end. Telephonic communication is available between both ends and the complete measurement of the distance takes possibly twenty minutes. This must be compared with the weeks that it would have taken to measure a similar length by stretching a tape between trestles 300 feet at a time.

The tellurometer can be used for many purposes other than measuring precise base-lines. In the Bahamas, for example, the secondary control of the island of New Providence was done entirely by tellurometer in a matter of three months, whereas by previous methods it would have taken at least nine months and would not have been so accurate.

Oil companies have used it to run large control-traverses around the area being prospected so that they can very rapidly provide a control onto which their seismic investigations can be plotted. In the Antarctic distances of fifty to seventy miles have been measured, linking up islands to the mainland that might otherwise never have been satisfactorily joined. The maximum distance measured on the surface by this means in a normal triangulation scheme was recorded by the Hydrographic Department of the Navy when a ninety-four-mile side of a triangle linking Grenada, Tobago and Trinidad was charted.

The greater distances of 200 miles and more referred to earlier in this article are measured by the radar technique known as Shoran. In this method an aircraft transmits a signal to a ground beacon which responds, and from the time taken the radius of the aircraft from the beacon can be determined. If responder beacon-stations are set up at either end of the required distance on the ground the aircraft can fly above and between the points, crossing the line in a figure-of-eight pattern and transmitting to the beacons continuously. By an inspection of the results the sum of the two minimum radii will provide the shortest distance between the two ground points. By this means triangulation schemes with very long sides can be built up and so link areas which are thousands of miles apart, with the minimum of ground observations.

The modern methods so far mentioned have been concerned with the fixing of topographica detail in order to make basic maps. The information required for special maps has in the pas been provided by geologists, seismologists and geographers working on the ground. Nowadays a large part of this material is derived by airborne recorders and from interpretation of air-photographs. It is now possible to carry and operate either in or from an aircraft in flight, many forms of scientific instruments such as magnetometers and scintillometers, the results being simultaneously recorded on a graph. It is interesting to note that an expedition working on the North Canadian Ice Shelf is recording sea sounding with the recorder in the helicopter and the oscillator suspended onto the ice, or attached to a raft towed by a helicopter. Again it is vital to be able to plot the information in its correct locality and a certain amount of ground information i also required—but very little compared with what would have been needed to get the same amount of information by ground methods only

In addition to these physical records a detailed interpretation of the photographs themselves i necessary and here again electronics have come to the aid of the surveyor. The perfect print was very rare occurrence, and shadows often mad interpretation of valleys or streets very difficult Today the exposure is automatically controlled by an electronic scanner when a print is being made and is varied so that the shadows can be penetrated without detriment to the other parts

In conclusion one might summarize the recen developments that have contributed most to th production of special maps as: electroni methods for measuring distances; the ability to record ground scientific phenomena by means o instruments carried in aircraft; and the very hig standard of air-photography made possible b better lenses and better printing processes.

Measuring a very accurate distance on the ground in 1847. A sketch by Sir J. F. W. Herschel, the astronomer, published by the Ordnance Survey